COTTON STORAGES PROJECT 2011

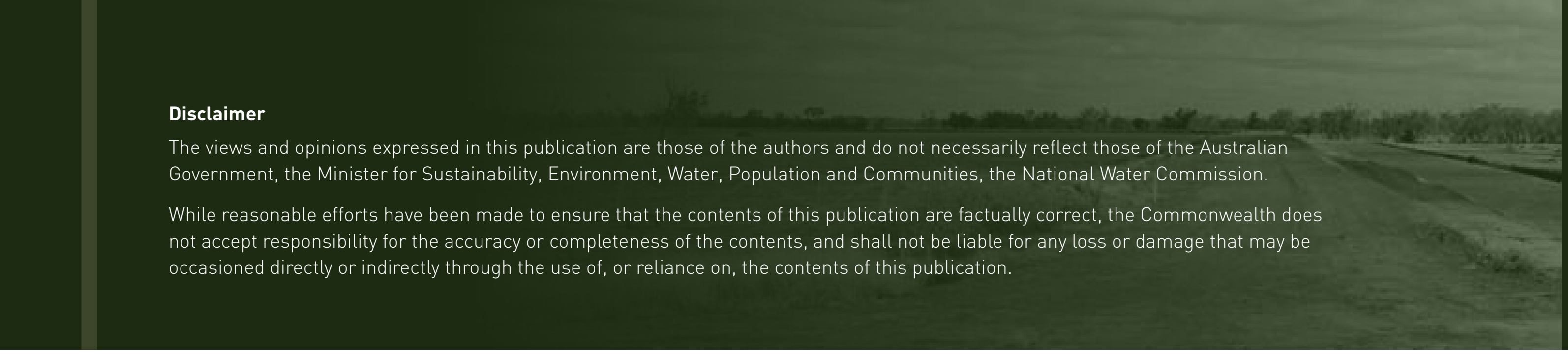
Storage Seepage & Evaporation

Final summary of results

A summary of the results from the measurement of seepage and evaporation losses from 136 on-farm storages across the cotton industry

Cotton Catchment Communities CRC

NCEA



Key Points

- 88% of storages had low seepage of less than 4 mm per day.
- In about 20% of cases, the measured seepage was in a different category to that estimated by the grower.
- Annual evaporation for individual storages (if storages held water year round) ranged from around 1m/year to just over 2m/year.

On-farm storages can be a major source of water loss on cotton farms. Previous studies in the Macintyre valley (Dalton 2001) indicated seepage losses of between 2% and 10% and evaporation losses of between 14% and 40% of all farm water in a year. In order to better understand the range of seepage and evaporation losses across the whole industry, the project "Measurement to Improve the Water Efficiency of On-Farm Storages in the Cotton Industry", was established in 2008 to undertake storage seepage and evaporation measurements.

This project was specifically designed to also encourage the ongoing measurement of storage seepage and evaporation losses using newly developed measurement technology. A network of consultants was utilised to undertake measurements for 136 storages across all cotton regions using the Irrimate™ Seeepage and Evaporation Meter.

Measurement Process

The Irrimate™ Seepage and Evaporation Meter is able to estimate seepage and evaporation losses from an entire storage, and is believed to be the only equipment available to achieve this. Most other methods for measuring evaporation and seepage (such as atmospheric flux techniques or infiltrometers) rely on point source measurements and do not give a value for the entire storage.

The meter includes a highly accurate pressure sensitive transducer (PST) which is installed under the water and is able to measure very small changes in water level. An accurate analysis of seepage and evaporation can usually be achieved with approximately 20 days of quality data. As periods of rainfall and storage inflow/outflow cannot be used, the equipment usually needs to be deployed for at least 5 weeks to ensure enough quality data is collected.

Data analysis is achieved by using regression techniques to compare measured water level changes and local evapotranspiration data. This process allows the evaporation and seepage components of the total loss to be separated, thus determining an average daily seepage rate and a dam evaporation factor (kdam), which can be used to convert a local estimate of evaporation to an actual rate of evaporation for a specific water storage.

Results

Table 1 presents a summary of the seepage and evaporation figures for all storages. It is suggested that the range of storage sizes evaluated, from 75 ML to 14,000 ML, would encompass the full size range of irrigation storages found throughout the cotton industry.

***Table 1** – Summary of key data*

	Mean	Minimum	Maximum
Seepage (mm/day)	2.3	0	38.1
Evaporation m/year	1.52	1.03	2.18
Dam Factor (k_{dam})	0.97	0.67	1.31
Storage Size (ML)	1,950	75	14,000
Storage Size (ha)[1]	44	1	303
Water Depth (m)[2]	3.5	1.0	9.1

[1] *Area data not available for the 4 storages located in Central Queensland*

[2] *Depth of water in storage at the time of equipment installation, not the depth of the storage*

Storages were located across all cotton growing regions (Figure 1), although seasonal conditions and the distribution of measurement equipment resulted in more measurements in the Condamine, Lower Balonne and Namoi catchments than in some other regions. Whilst the total number of storages within the industry is not accurately known, it is likely that the sample size (136) represents no more than 10% of all storages in use.

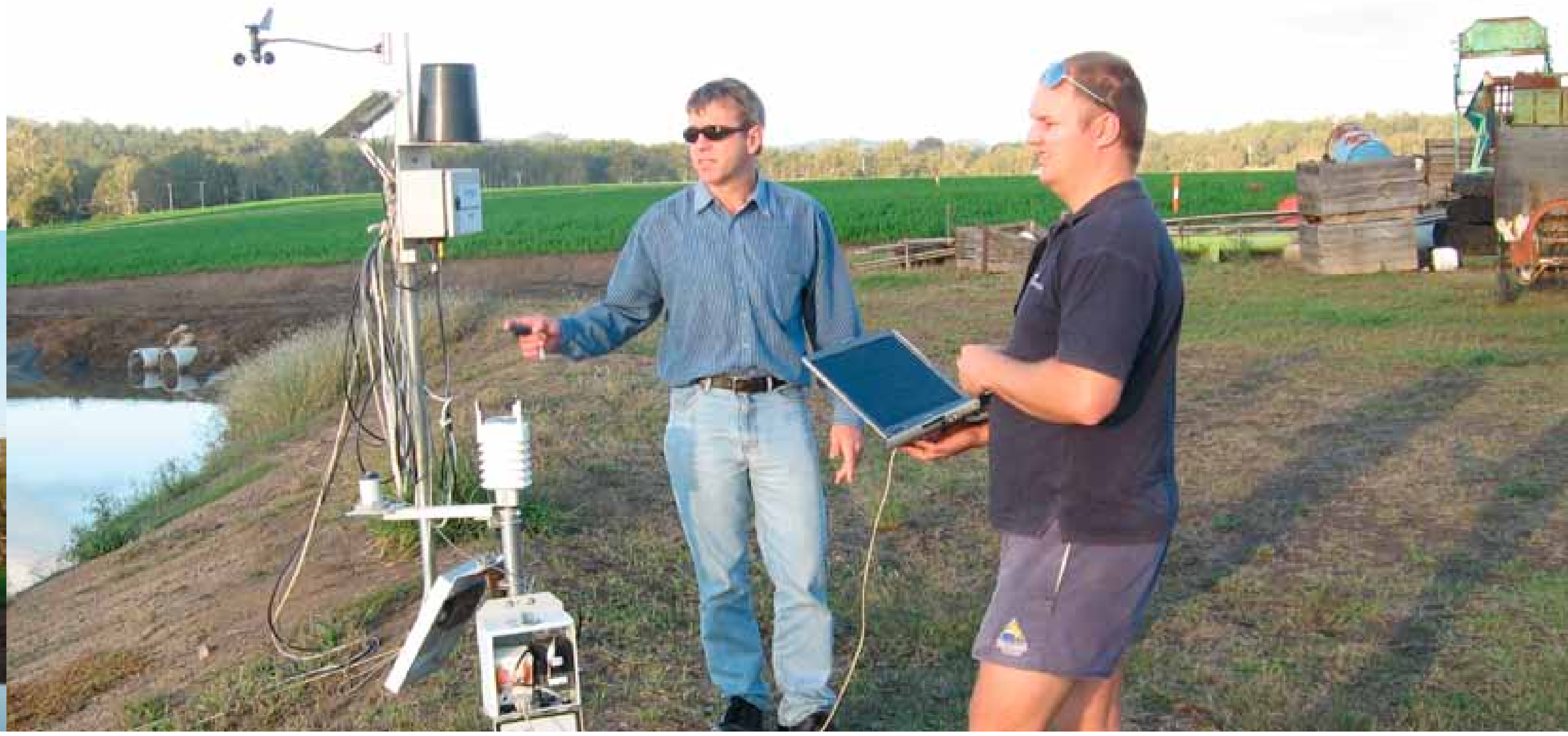
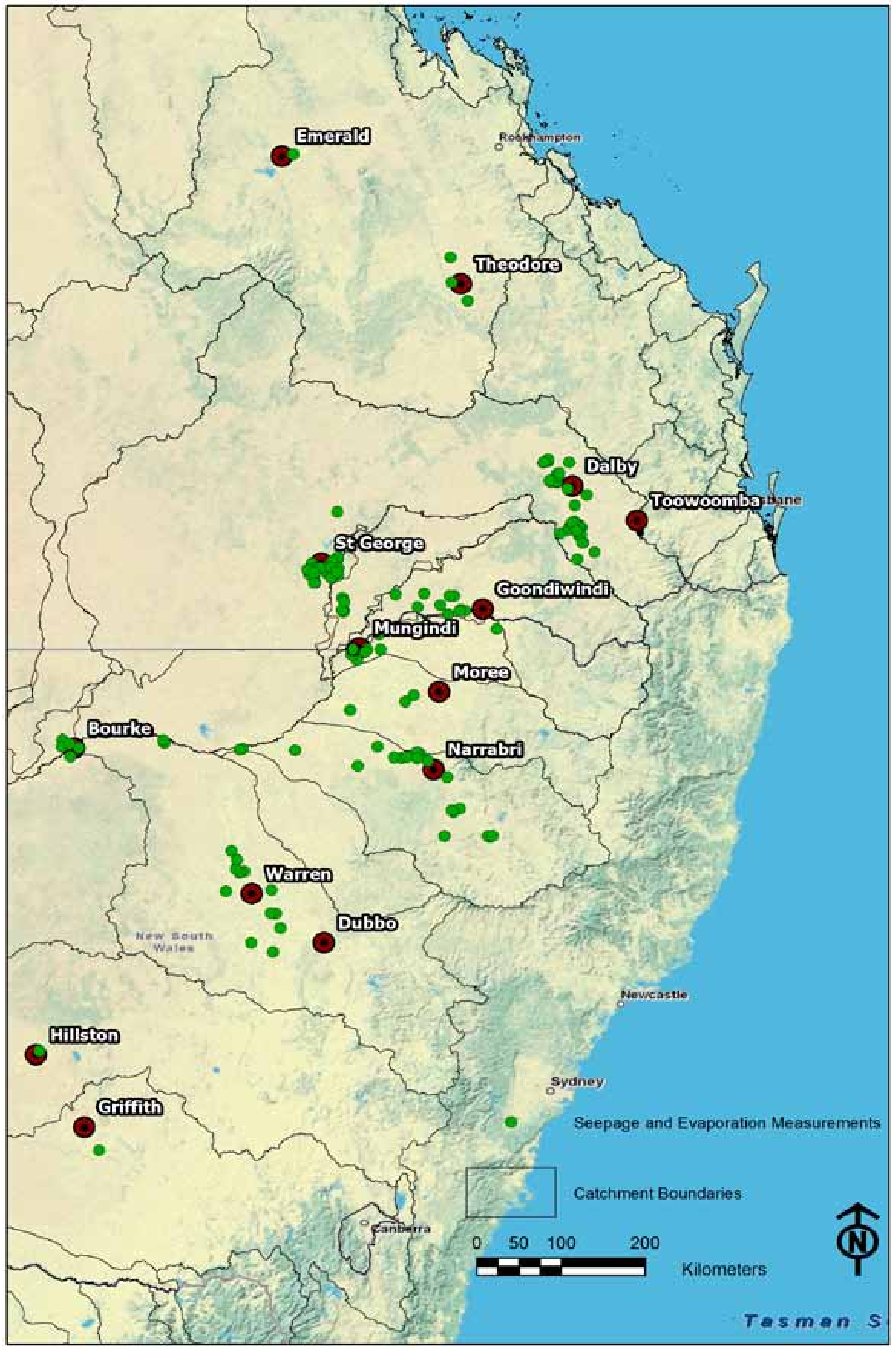


Figure 1 – Location of measured storages



Seepage

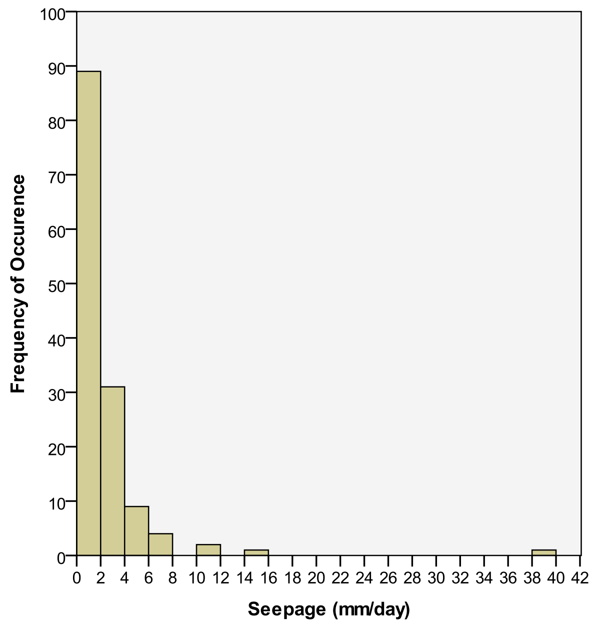
Figure 2 shows the distribution of seepage results obtained. Significantly, 88% of storages (120) had seepage of less than 4 mm/day, a rate which could be considered low, with most of these (89) indicating extremely low seepage of less than 2 mm/day. A single outlier exists for a storage that was known to leak very badly and was confirmed to have seepage of 38 mm/day. This storage contained water during the measurement period for the first time in over 6 years (since being purchased by the current owner) and was drained within a matter of weeks due to the excessive loss being experienced.

As part of the measurement process, growers were asked to estimate their level of seepage before the evaluation was conducted (Figure 6). Whilst most grower estimates were reasonably close to the measured results, there were about 20% of cases where the measured seepage could be classified differently to the estimate provided.

For example, of those growers who estimated their seepage as low, two had a measured rate above 7 mm/day which could be classified as high, whilst another three had a measured rate of above 4 mm/day which could be classified as medium. However it should be noted that numerical guidance was not provided to growers, therefore individual growers could have a different concept of low, medium or high seepage.

In one case where the grower estimated a very high seepage rate, the measured seepage rate was quite low at less than 3.5 mm/day. Such a case illustrates the importance of objective measurement before taking action to address perceived seepage loss.

Figure 2 – Histogram of all seepage results



Seepage was not found to vary with soil type, storage shape or between regions. However, evaluations were unevenly distributed across these categories, making it difficult to draw accurate conclusions. The range of soil types encountered and the number of storages constructed on lighter soil types was unexpected (Table 5). However higher seepage rates were not solely associated with lighter soil types. It is possible that the rudimentary surface soil classification achievable within the resources of this project may not accurately represent subsoil conditions (including compaction) that could significantly influence seepage.

Figure 3 – Histogram of measured seepage results for each category of grower predicted seepage. The outlier (38mm/day) has been removed for improved clarity but was correctly estimated by the grower as very high.

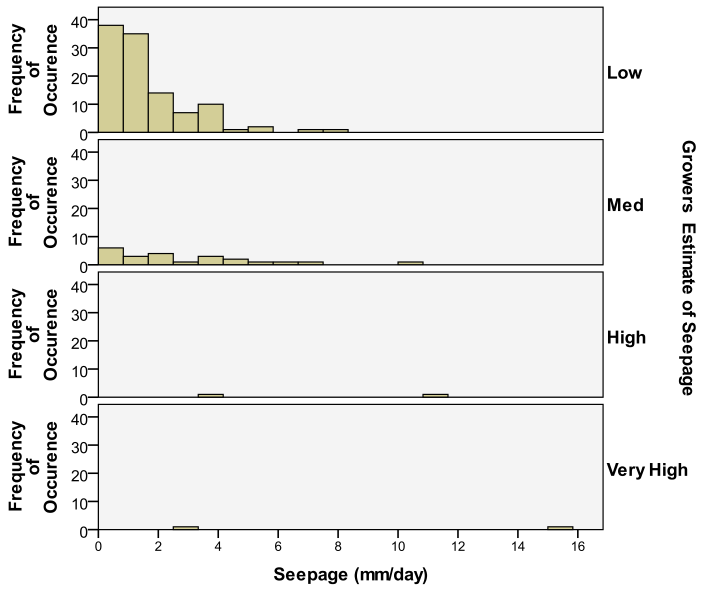


Table 2 – Measured seepage for a range of different surface soil types

Soil Type	Sample size	Measured Seepage Rate (mm/day)		
		Mean	Minimum	Maximum
Heavy Clay	23	2.0	0.1	5.0
Medium Clay	57	2.7	0.1	38.1
Light Medium Clay	29	1.5	0.0	4.5
Light Clay	13	3.2	0.5	11.5
Clay Loam	4	1.4	0.5	2.2
Sandy Clay Loam	5	1.4	0.5	3.7
Sandy Clay	6	2.2	0.5	3.5

In terms of storage size, it might be expected that larger storages, with less compaction over the base during the construction process and with greater potential for soil variability, might have typically higher seepage losses. However, all of the higher seepage results were obtained from storages of smaller volumes or surface areas.

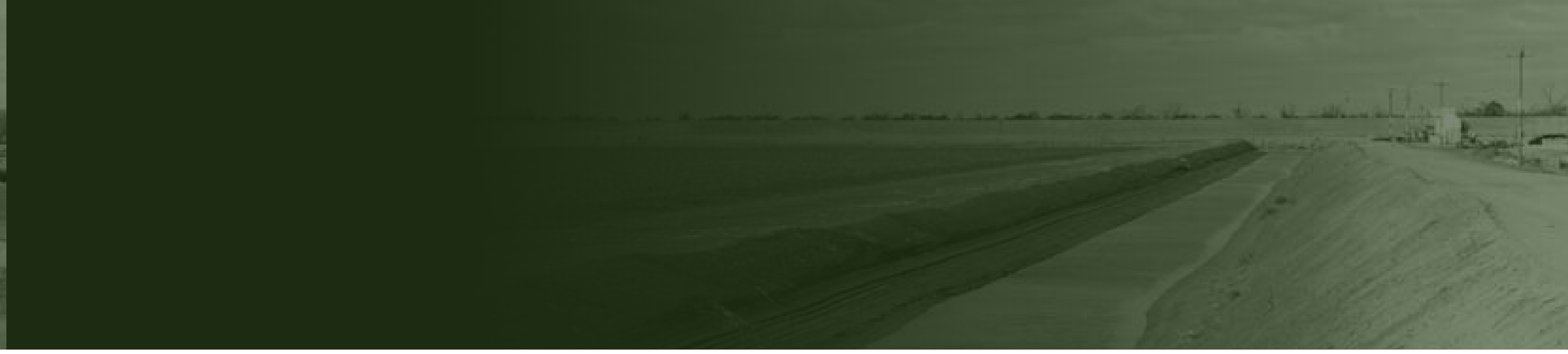
The data from four storages was also analysed to determine the effect of water depth on seepage rate. Whilst conventional wisdom suggests that greater water depths will result in higher rates of seepage, soil hydraulic conductivity and the complicated nature of some loss pathways will also have a major effect.

This is reflected by the results in Table 3, which show that two of the four storages had lower measured seepage when the water depth was greater. Storage D showed higher seepage when water depth was 5 m compared to 4 m, but no further increase in seepage when water depth was 6 m. This limited analysis most likely suggests that for storages with low seepage, variations in water depth cause changes in seepage that are within the bounds of measurement error.

Further detail of this analysis is contained in a separate fact sheet available on the Cotton Catchment Communities CRC website (www.cottoncrc.org.au).

Table 3 – The effect of water depth on seepage rate

Storage	Approximate Water Depth (m)	Seepage Rate (mm/day)
A	2.5	3.9
	5.0	2.6
B	1.0	1.7
	1.6	2.2
C	1.7	0.8
	2.0	0.5
D	4.0	1.5
	5.0	2.4
	6.0	2.4



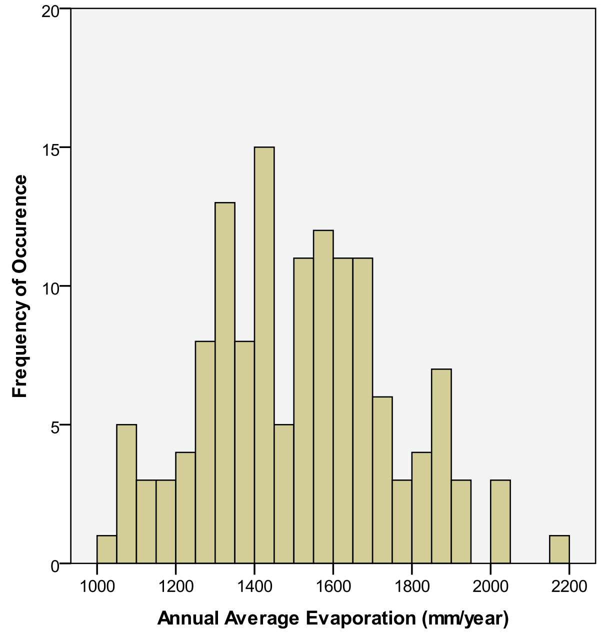
Evaporation

Comparison of evaporation measurements is not straightforward because the measurement technology was typically only deployed for a period of 1 to 2 months. Therefore, measured evaporation during the period of deployment will depend entirely on the climatic conditions experienced at that time. Hence it is most appropriate to present typical annual evaporation figures that take seasonal conditions into account.

Evaporation from the water surface will be influenced by a range of site specific variables including wind, surface water temperature, surrounding features (trees, hills), proximity to other water large water bodies, etc. Therefore, a 'dam factor' is used to estimate evaporation for individual storages. This dam factor (Kdam) is measured during the period of deployment and can be applied to climatic data recorded over one or more years.

The average annual evaporation from all storages (following application of the relevant kdam for each storage) is presented in Figure 4.

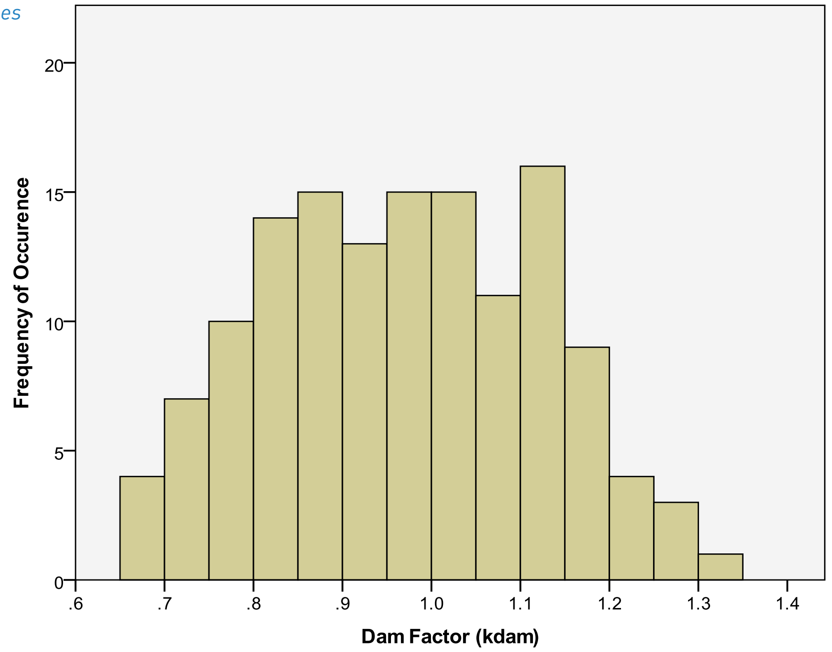
Figure 4 – Histogram of potential annual evaporation for all sites after application of individually-determined dam factors



For consistency, all dam factors reported within this project relate to SILO FAO56 ETo data. The range of dam factor values is indicated in Figure 12. The majority (82%) of dam factors lie between 0.8 and 1.2.

Dam factor was compared to a number of storage characteristics such as local average rainfall, water depth, surface area, storage location (latitude) and the characteristics of the surrounding area. However, no correlation between dam factor and any of these parameters was found.

Figure 5 – The range of calculated dam factor values



References

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Acknowledgements

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