Hydrological modelling dataset

Report 1: Infrastructure and hydro constraint attributes

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Version control

Version	Date amended	Comments
1.0	16 November 2015	Draft report for review
1.1	8 December 2015	Final report
1.2	13 July 2018	Updated

Executive summary

A large proportion of New Zealand's electricity needs are met by generation from hydro power. Information about the distribution of inflows and the capability of the various hydro systems is necessary to ensure a reliable, competitive and efficient market and electricity system.

The hydrological modelling dataset (HMD) contains hydrological information made available by the Electricity Authority. The dataset was known as the SPECTRA update until 2010. In 2015 the dataset was revised to become the HMD; a comprehensive dataset that can be relied upon by modellers and analysts to test scenarios, provide commentary and inform decisions.

The HMD is comprised of data provided by hydro generators and supplemented with some from other sources. These parties are acknowledged for their contribution and for making this data available.

The HMD consists of three main components:

1. Infrastructure and hydrological constraint attributes

   This dataset records standing information about the capability of the main hydro schemes.

2. Flows including inflows, outflows, and flows within rivers

   A time series dataset which records inflows for reservoirs and flows at various existing or potential hydro generating sites.

3. Storage and spill

   A time series dataset which records historical storage for the main hydro schemes.

This information paper describes the first component of the HMD, the infrastructure and hydro constraints.

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1 Infrastructure and hydro constraint attributes

1.1 Infrastructure and hydrological constraints together define the capability of hydro generating schemes to store energy and produce electricity. This dataset records material attributes of generating plant and consents that govern storage volumes and flows associated with the main reservoirs from 1980 onwards.

1.2 The information has been collected from plant owners and consenting agencies. It is needed to accurately derive the specific energy (in terms of electricity potential) of water in each reservoir and energy storage in GWh.

1.3 The dataset tracks changes in these attributes through time providing record of plant and hydro scheme capability. Understanding historical capability is useful – especially when undertaking analysis based on historical outcomes.

2 Infrastructure attributes

2.1 Infrastructure attributes are those defined primarily by the engineering aspects of a hydro generating station. The dataset captures both the capacity of the station and a plant factor that defines the relationship between flow and energy production. Table 1 describes the fields in the dataset.

2.2 Any infrastructure changes that alter either the plant factor or the capacity should be captured by the owner or station operator and passed on to either the system operator or the Electricity Authority (Authority). Examples could be re-runnering the hydro units, extending the capacity of the units by rewinding the generators, or even changing the operating regime of the reservoir to increase the average head during operation of the station.

2.3 Nominally, plant factors recorded are intended to represent an average factor over the last three years, unless an obvious intervention to the plant has taken place.

3 Hydrological constraints

3.1 Hydrological constraints apply only to reservoir or hydro arc plant types, and place restrictions on storage or flows. The list of hydro arcs is not exhaustive. Additionally, hydro nodes or junctions are not captured in the dataset. Modellers will have to take some additional details into account in their models.

Storage constraints

3.2 This dataset records the capacity of reservoirs to store water. Reservoirs generally have standard operating ranges defined by consents (or engineering features). In some cases consents vary by time (e.g. month or season). In addition, reservoirs can have contingent storage that becomes available when certain conditions are met. This additional storage has a material impact on the system, participant behaviours, and when assessing shortage risk or monitoring security of supply.

3.3 Some controls or restrictions on reservoirs can be complex and this dataset does not attempt to capture all these nuances – especially around flood control or management.

3.4 There are four types of storage that are represented in this dataset:

(a) Active storage capacity

(i) Operational storage able to be used in the normal operation of the system by the scheme or plant operator. This storage may have seasonal consents, increasing the active storage capacity at certain times of the year.

(ii) A seasonal consent that lowers the allowable operating minimum will immediately make additional stored water available (i.e. increase active storage available to the generator). Conversely, a seasonal consent that raises the operating maximum will increase the active storage capacity available to be utilised by the generator, but clearly won't make more stored water available.

(b) Consented contingent storage capacity

(i) Additional storage capacity available below the active storage range of a reservoir which becomes available to the generator when certain conditions are met. As this storage capacity is below the active storage it provides access to additional stored water or energy. Consented contingent storage and its associated conditions are defined in a consent or similar document.

(c) Available contingent storage capacity

(i) Recognises that although an operator may have consent to draw down reservoir levels and use storage, there may be other engineering-based or practical limitations that constrain the use of the storage. In terms of security of supply, this is the best measure of additional storage that will practicably become available when the relevant triggers are met.

(d) Active contingent storage capacity

(i) Records when consent conditions are met to trigger the available contingent storage capacity. The capacity and dates within the dataset are adjusted accordingly. The triggering and use of active contingent storage is recorded in the third part of this dataset. Normally active contingent storage will be recorded as zero.

Flow constraints

3.5 Hydro systems can be complex and there are often multiple paths that water can take in a scheme. We've called these paths hydro arcs. Each of these hydro arcs can have a constraint that limits the operation of the hydro scheme in some way. The HMD captures the material restrictions to flow within the schemes enabling modellers to better approximate the true capability of the system.

4 Summary of infrastructure and hydro constraint fields

4.1 Table 1 records a summary and description of the fields in the dataset.

Table 1: Infrastructure and hydro constraint attributes

Field name	Format	Description
Plant group	text	Describes the hydro scheme that the plant is part of.
Island	2 char code	North Island (NI) or South Island (SI).
Site	3 char code	Provides a site code that links the individual station or asset to the wholesale market data. Some new codes

Field name	Format	Description
		have been introduced for hydrological sites that are not used within the market systems such as pricing or reconciliation.
Plant group rank	numeric	Rank applies a relative order for each asset or feature in the group or scheme. NZ hydro chains are linear (for generation) so this simple linear ranking methodology holds true. We use the first digit to rank **reservoirs** by the specific energy of the water within them - plant group rank 1 has the highest energy per cubic meter of water within the scheme. Reservoirs of equal rank are in the same stage in the hydro scheme. The first decimal value ranks hydro generating stations fed directly from the reservoir (without going through another reservoir). The second decimal value records hydro arcs or flow paths in their relative order from the reservoir. In all cases, equal ranking indicates parallel hydro arcs, hydro plant or reservoirs where storage has equivalent specific energy to the scheme. Sequential ranking indicates series flow. For example: 1.01 and 1.11 would be parallel hydro arcs from the first reservoir in the scheme. 1.01 refers to flow leaving the reservoir without going through a generator. 1.11 refers to the flow through the hydro station. We do not record information for all flow arcs in the hydro scheme - only those that have material impact on the operation of the scheme. See the schematic in Figure 1.
Plant type	text	Plant types are: • Reservoir • Hydro • Hydro arc
Sub type	text	Further breakdown of plant type. Reservoirs are either: • Controlled • Run of river. Hydro plant is recorded as hydro and not broken down into the various types of turbine technology (Francis or Kaplan etc.). Hydro arcs are one of: • River • Canal • Station flow • Spill flow.
Description	text	A description of the reservoir, hydro plant or hydro arc.

Field name	Format	Description
Attribute	text	Reservoir plant types have attributes of: • Active storage capacity (million cubic meters or Mm3) • Consented contingent storage capacity (Mm3) • Available contingent storage capacity (Mm3) • Active contingent storage capacity (Mm3) See section 3.4 for a description of these types. Hydro plant has attributes of: • Plant factor - nominally a three year average (cumecs/MW) • Generating capacity (MW) Hydro arc plant types have attributes of: • Max flow (cumecs)[1] • Min flow (cumecs) • Min monthly volume (Mm3) In the case of spill flow (a type of hydro arc), we identify the specific mechanism where it is known (e.g. max siphon flow).
Value	numeric	Records the numeric value or quantity for the attribute. Null should be read as there is no limit for this attribute. A null value does not mean that there is not another constraint restricting the attribute value.
Unit	text	The unit for the numeric value of the related attribute.
Start date	yyyy-mm-dd	Date in ISO format for when an attribute, value, schedule, source or consent begins to apply. For example, when infrastructure was modified or upgraded, a consent was renewed or amended, or available contingent storage capacity is triggered (i.e. becomes active contingent storage capacity).
End date	yyyy-mm-dd	Date in ISO format for when an attribute, value, schedule, source or consent ceases to apply.
Schedule	cron expression	Schedules apply only to hydrological constraints; either reservoir storage volumes (with a seasonal consent) or flow in hydro arcs. They make use of standard cron style expressions. Cron expressions are made of up to six fields that combine to represent a set of time spans. • Minute (0-59) • Hour (0-23) • Day of month (1-31) • Month (1-12) • Day of the week (0-6, where Sunday=0) • Year (0001-9999)

[1] A cumec is a flow rate measures as a cubic meter per second.

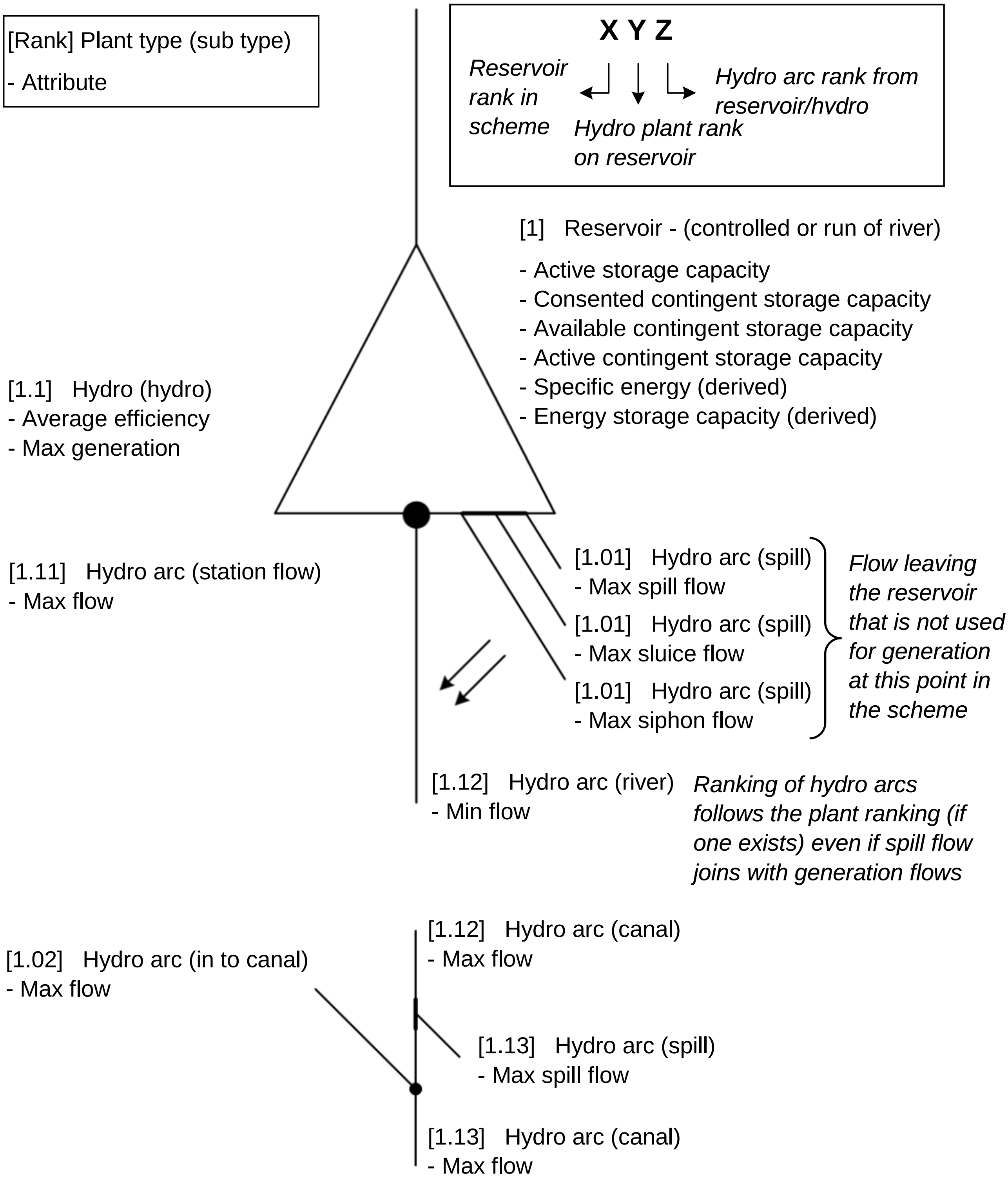
Field name	Format	Description
		Each field can include either; (a) an asterisk that covers the full allowable range, (b) an individual value, (c) a range of values, or (d) a list of both values and/or ranges. Fields are separated by spaces, lists by commas, and ranges are denoted by a hyphen. For example, a schedule that applies to office hours over summer (ie Mon-Fri, 9am-5pm, Oct-Mar), would appear as: * 9-17 * 1-3,10-12 1-5 * For more information see: https://en.wikipedia.org/wiki/Cron#CRON_expression
Source	text	The entity that provided the information.
Consent	alphanumeric	The relevant consent or document number.
Notes	text	Additional notes describing relevant contextual information. For example lake levels (that define the volume), a trigger condition for contingent storage, or a consenting body for a hydro constraint.

Source: Electricity Authority

5 Ranking method

5.1 Reservoirs, hydro plant and hydro arcs in each hydro system are ranked; providing information on their relationship and dependence on each other in a simple numeric format. However, this information does not provide complete information on all nodes (start and end points) or hydro arcs. Users of the dataset will need additional information or knowledge to fully develop accurate flow system models. Figure 1 illustrates the linear ranking method adopted in the dataset.

Figure 1: Ranking within hydro schemes



Source: Electricity Authority

6 Maintaining this dataset

6.1 The infrastructure and hydrological constraints dataset will be maintained as changes occur. If the infrastructure capability or consent conditions change, please let either the Authority know by contacting emi@ea.govt.nz, or the system operator through their consultations or discussions on security of supply.