Water in artificial reservoirs: moving the production boundary to create an inventory

Issue D4 SEEA CF update

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Australian National University

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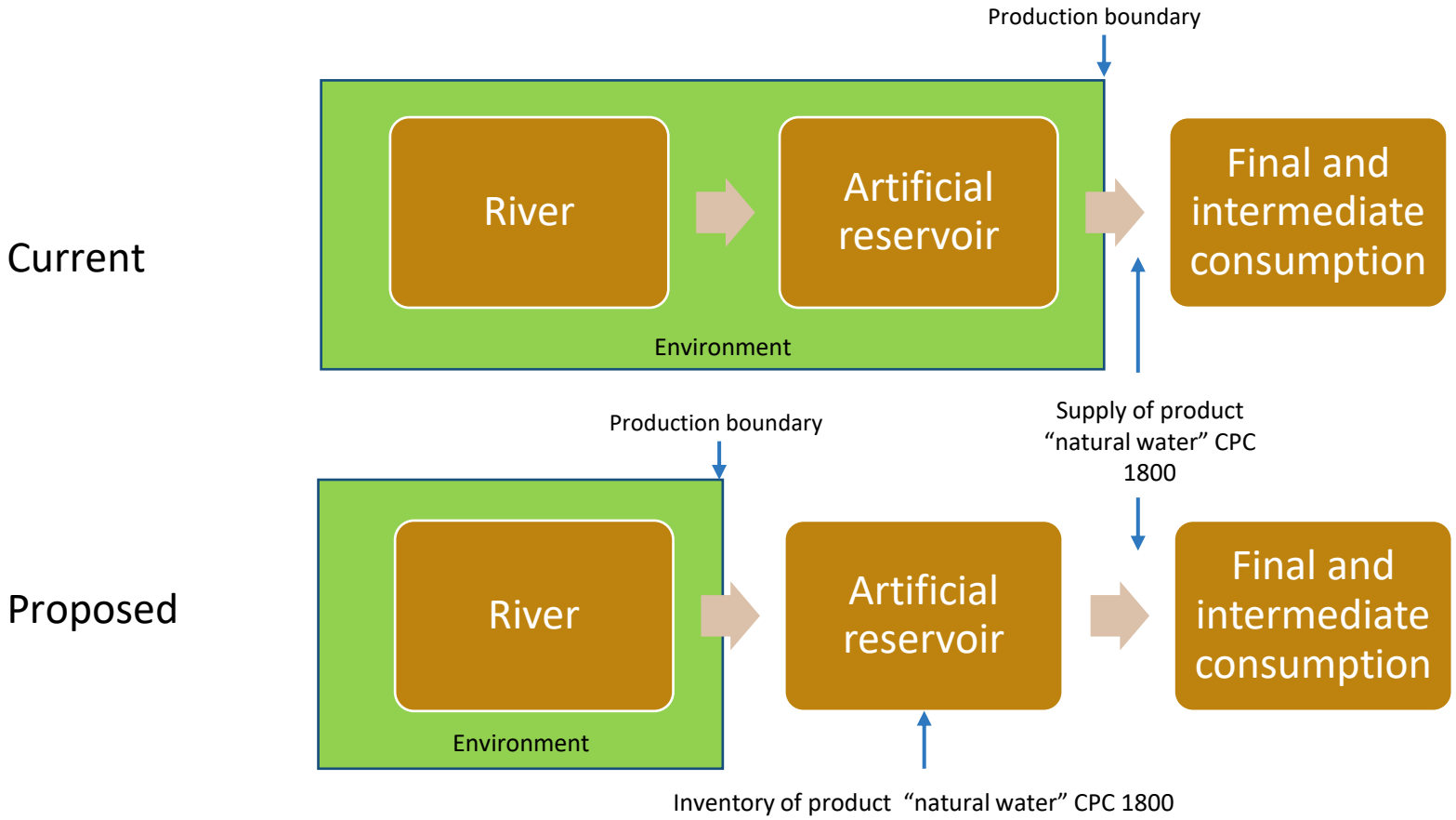
Why is it important?

Artificial reservoirs are an essential part of water management, particularly in countries and regions with

- Low water availability
- Variable water availability
- Changing availability due to global warming
- Growing demand

Current SEEA-CF accounting does not fully describe the system, limiting its usefulness

Current and alternative treatment



Defining artificial reservoirs

SEEA-CF:

- purpose-built reservoirs used for the storage, regulation, and control of water resources (para 5.477).

International Commission on Large Dams (ICOLD)

- an artificial barrier that has the ability to impound water for the purpose of storage or control of water.

Artificial reservoirs can have more than one purpose

- Scope is water stored for supply to the economy (e.g. Households for drinking, agriculture for irrigation and energy for hydro-electricity)

Other human-built infrastructure, such as pipes, canals and drains, are connected to artificial reservoirs and water treatment facilities

Reservoir water as a produced asset - inventory

SNA Assets

Water is held in reservoirs and supplied or held over time with benefits accruing to the economic owner. The water volume and water value is carried forward from one accounting period to another.

Produced asset - inventory

- Reservoir water (natural water CPC 1800) is an output of production (see below).
- Without human intervention there would be no reservoir water.
- The water has not come into existence, but it would not be in the reservoir without a production process that stores water
- At present production is recognised when water leaves the reservoir (it didn't come into existence at the dam wall)
- **The question is not whether it comes into existence , but when it is produced**

Production

- Production of reservoir water (natural water CPC 1800) is an activity carried out under the responsibility, control and management of an institutional unit (e.g., enterprises and establishments classified to Water Supply Industry ISIC 36), it uses inputs of labour (dam operation and maintenance), capital (e.g. dam walls), and goods and services (electricity, concrete, chemicals) to produce outputs of goods and services (i.e. natural water CPC 1800).

Produced boundary

- Reservoir water is produced in the current period (inflow in current year) or in an earlier period (inflows from previous years) held in storage as an inventory for distribution
- Reservoir water may be distributed or stored for use at a later date

Consistency of treatment of natural resources and production

Plantation forests vs. natural forests

Aquaculture vs. wild fish

- Production of recorded at different times, depending on the degree of human intervention

Mining

- Minerals are displaced in space and time via extraction, but not physically transformed

Other implications

- Evaporation and seepage for artificial reservoirs are explicitly recorded as losses (Issue B2) and a use by the owner/operator of the reservoir (e.g., water supply industry, ISIC 36)
- Rainwater tanks and farm dams are also inventories
- Aquifer recharge may also be recorded as an inventory
- Reservoir water included in national balance sheets

Comment summary

Several online comments

Many during the LG meeting both in the session and in outside discussions

- All constructive
- Overall support and general agreement
- The obstacles are mostly practical
- Some questions and comments on SUT
- Several observations on links to the SNA and other cross-cutting issues
- No comments on the proposed text

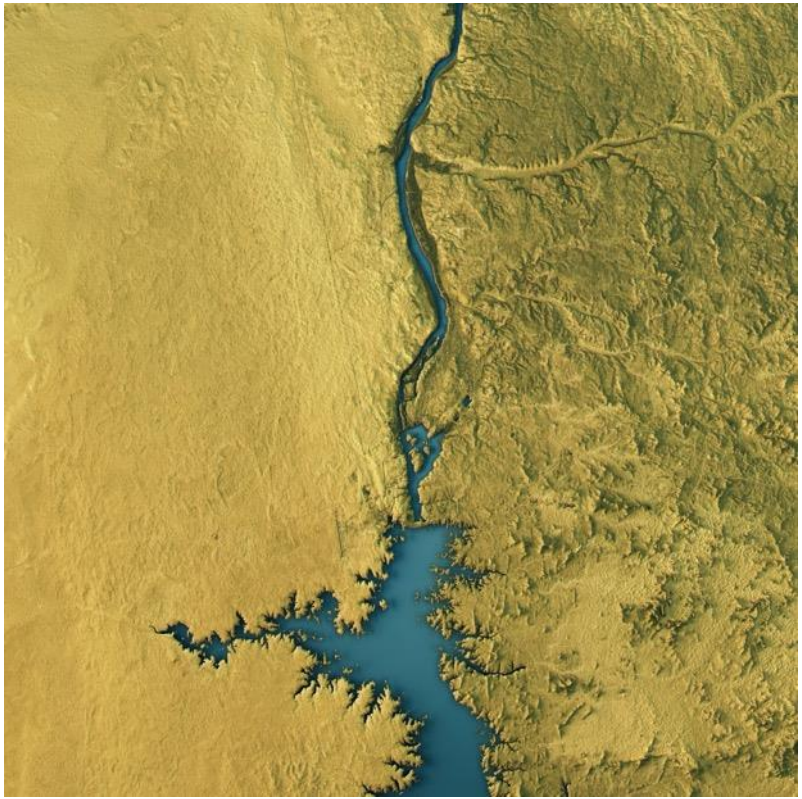
Practicalities

- Lots of countries produce water PSUT, and water asset accounts (two of the most commonly produced accounts in the world)
- The updated PSUT uses some data currently included in the asset account
- The PSUT only records changes in inventory (i.e. a total inventory is not needed for the PSUT)
- Large reservoirs typically measure inflows and outflows
- Evaporation is relatively easy to calculate
- Smaller artificial reservoirs like farms dams and rainwater tanks, are more difficult to estimate

Summary of proposed change

Recognising water in artificial reservoirs as an inventory:

- Applies the SNA definition of production
- An inventory is created when water enters artificial reservoirs
- The water SUT is adapted by adding a "changes in inventory" entry and splitting the water supply industry into water storage and water distribution
- The adapted SUT uses entries from the current water asset account
- The water asset account remains unchanged
- Practical definition and measurement challenges remain, but are no different from those that exist now



Conclusion

Water is in artificial reservoirs because of major human interventions

- Reservoirs are fundamentally different from other surface water bodies
- Current accounting treatment hides the economic and environmental significance of reservoirs.

Solution

- Recognise the human intervention
- Record water in reservoirs as an inventory

Proposed changes to recording:

- No change to the asset account
- Amend the supply and use table to include
  - a change in inventories in artificial reservoirs
  - Split water supply industry into water storage and water distribution

Questions

The questions are relevant to the current or alternative treatments

When is water be produced and can it be stored for future use?

To what degree, if any, should the recording be dictated by:

- Practical measurement considerations?
- The implications for the SNA?
- Likelihood of uptake by national accountants?

What additional guidance is needed on:

- The definition and delineation of artificial reservoirs
- Measurement of stocks and flows

How to effectively coordinate issue D4 with other issues in the SEEA-CF update?

- Water valuation (D7), links to SEEA EA (A1), treatment of losses (B2), linking stock and flow accounts (A8), SNA consistency (A9), links to policy (A6),

THANK YOU

Contact

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Current and proposed treatment does not affect the water asset account

The water asset account

- Identifies artificial reservoirs, lakes, rivers and streams, groundwater, snow, ice and glaciers
- Includes entries for and inflows, abstraction and outflows
- Abstractions are from water resources are shown as the supply of "Natural water" CPC 1800 from environment in the PSUT

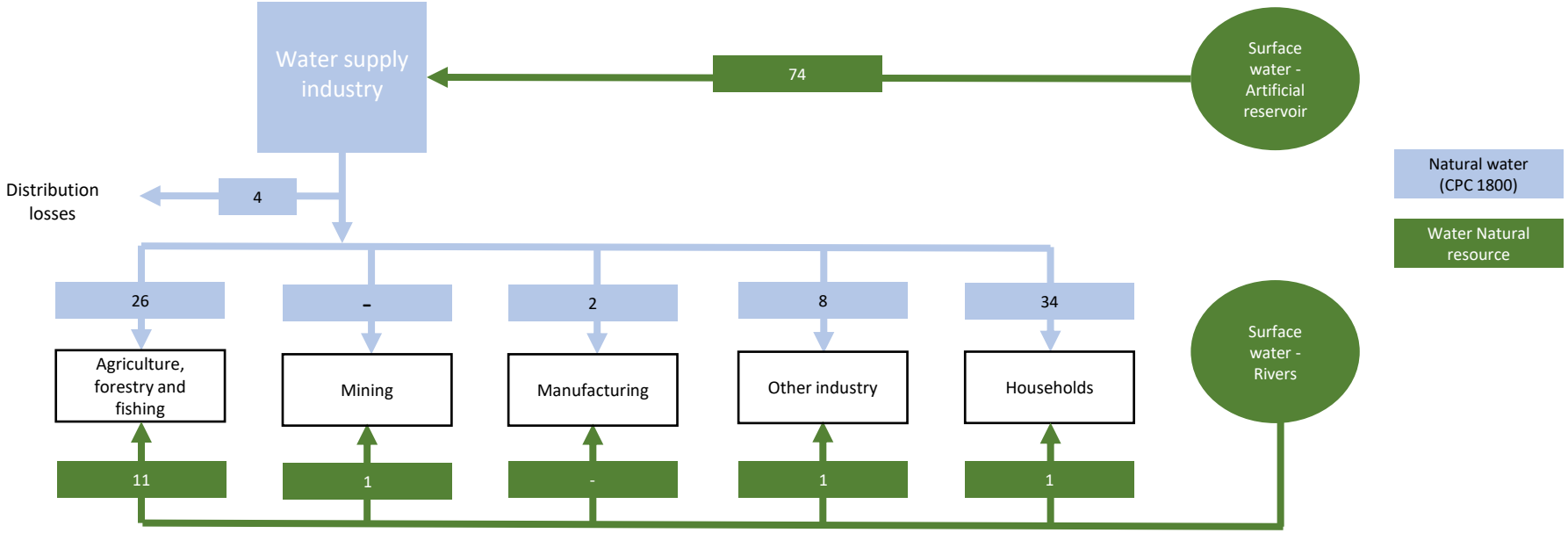
The proposed treatment affects the SUT

- Inflows to artificial reservoirs would be shown as the use of the natural resource water by the water supply industry (ISIC 36) supplied by the environment
- Abstractions from artificial reservoirs remain a supply of "Natural water" CPC 1800 by the water supply industry

Physical asset account for water resources (*cubic metres*)

	Type of water resource						
	Surface water				Groundwater	Soil water	
	Artificial reservoirs	Lakes	Rivers and streams	Glaciers, snow and ice			Total
Opening stock of water resources	1 500	2 700	5 000		100 000	500	109 700
Additions to stock							
Returns	300		53		315		669
Precipitation	124	246	50			23 015	23 435
Inflows from other territories			17 650				17 650
Inflows from other inland water resources	1 054	339	2 487		437	0	4 317
Discoveries of water in aquifers							
Total additions to stock	1 478	585	20 240		752	23 015	46 071
Reductions in stock							
Abstraction	280	20	141		476	50	967
for hydropower generation							
for cooling water							
Evaporation and actual evapotranspiration	80	215	54			21 125	21 474
Outflows to other territores			9 430				9 430
Outflows to the sea			10 000				10 000
Outflows to other inland water resources	1 000	100	1 343		87	1 787	4 317
Total reductions in stock	1 360	335	20 968		563	22 962	46 188
Closing stock of water resources	1 618	2 950	4 272		100 189	553	109 583

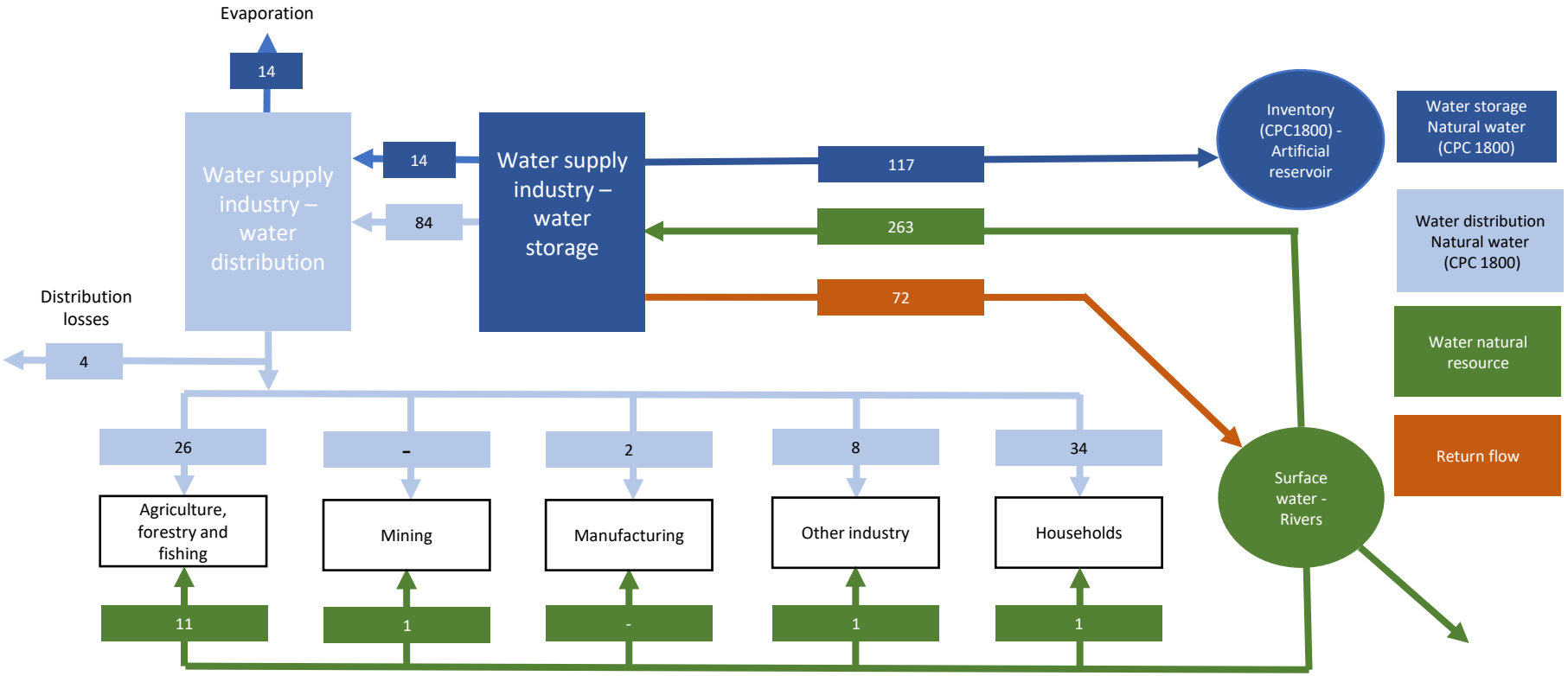
Reservoir water as a natural resource (non-produced asset), million m^3 – wet year



Current treatment, water as a natural resource, wet year, million m^3

		Economy							Environment	Total
Million m3		Agriculture, forestry and fishing	Mining	Manufacturing	Water supply	Other industry	Households	Import (supply) / Export (use)		
Supply										
Natural resouce										
	Artificial reservoirs								74	74
	Lakes								0	0
	Rivers								14	14
	Groundwater								0	0
	Total natural resource								*88*	*88*
Product										
	Natural water (CPC 1800)				74					74
Use										
Natural resouce										0
	Artificial reservoirs				74					74
	Lakes									
	Rivers	11	1			1	1	0		88
	Groundwater									
	Total natural resource	*11*	*1*	-	*74*	*1*	*1*	-		*88*
Product										
	Natural water (CPC 1800)	26		2	4	8	34	0		74

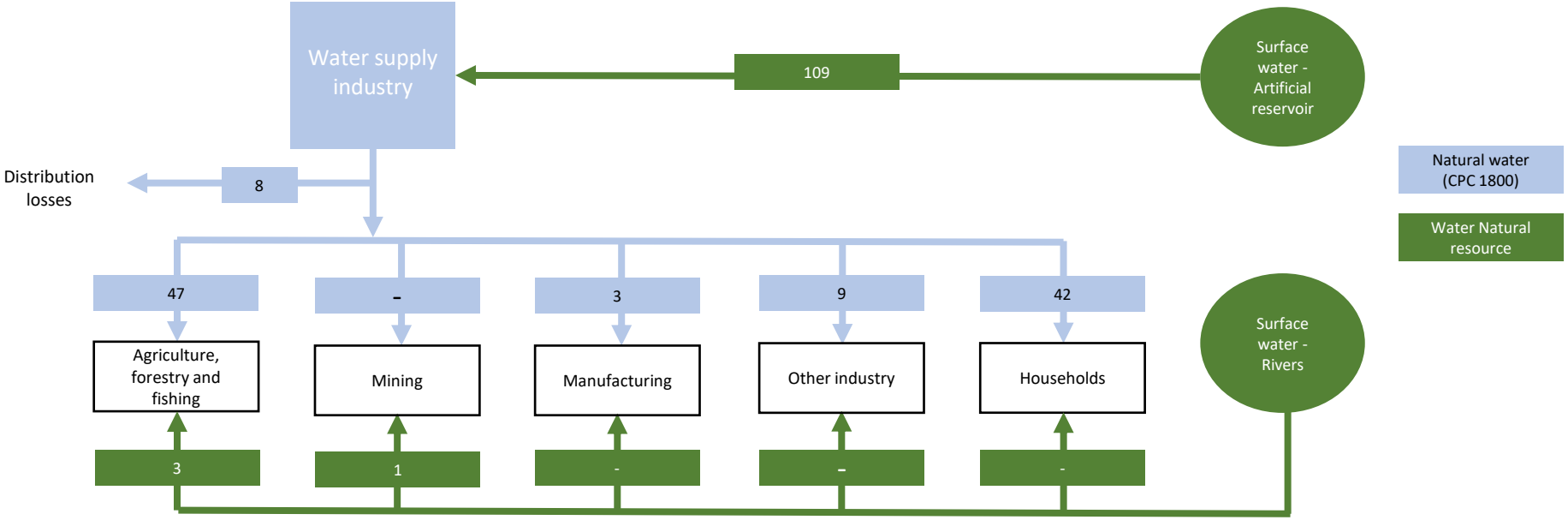
Reservoir water as an inventory (produced asset), million m^3 – wet year



Proposed treatment, water in artificial reservoirs as an inventory, wet year, million m^3

		Economy										
Million m3		Agriculture, forestry and fishing	Mining	Manufacturing	Water supply -storage	Water supply - distribution	Other industry	Households	Change in inventory	Import (supply) / Export (use)	Environment	Total
Supply												
Natural resouce												
	Lakes										0	0
	Rivers										277	277
	Groundwater										-	-
	Total natural resource											*277*
Product Natural water (CPC 1800)												
	Storage				117							117
	Distribution					74						74
	Total product	-	-	-	*117*	*74*	-	-	-	-		*191*
Return flow					72							72
Use												
Natural resouce												
	Lakes											
	Rivers	11	1		263		1	1				277
	Groundwater											
	Total natural resource	*11*	*1*	-	*263*	-	*1*	*1*	-	-		*277*
Product Natural water (CPC 1800)												
	Storage				14				103			117
	Distribution	26		2		4	8	34				74
	Total product	*26*	-	*2*	*14*	*4*	*8*	*34*	*103*	-		*191*
Return flow											72	72

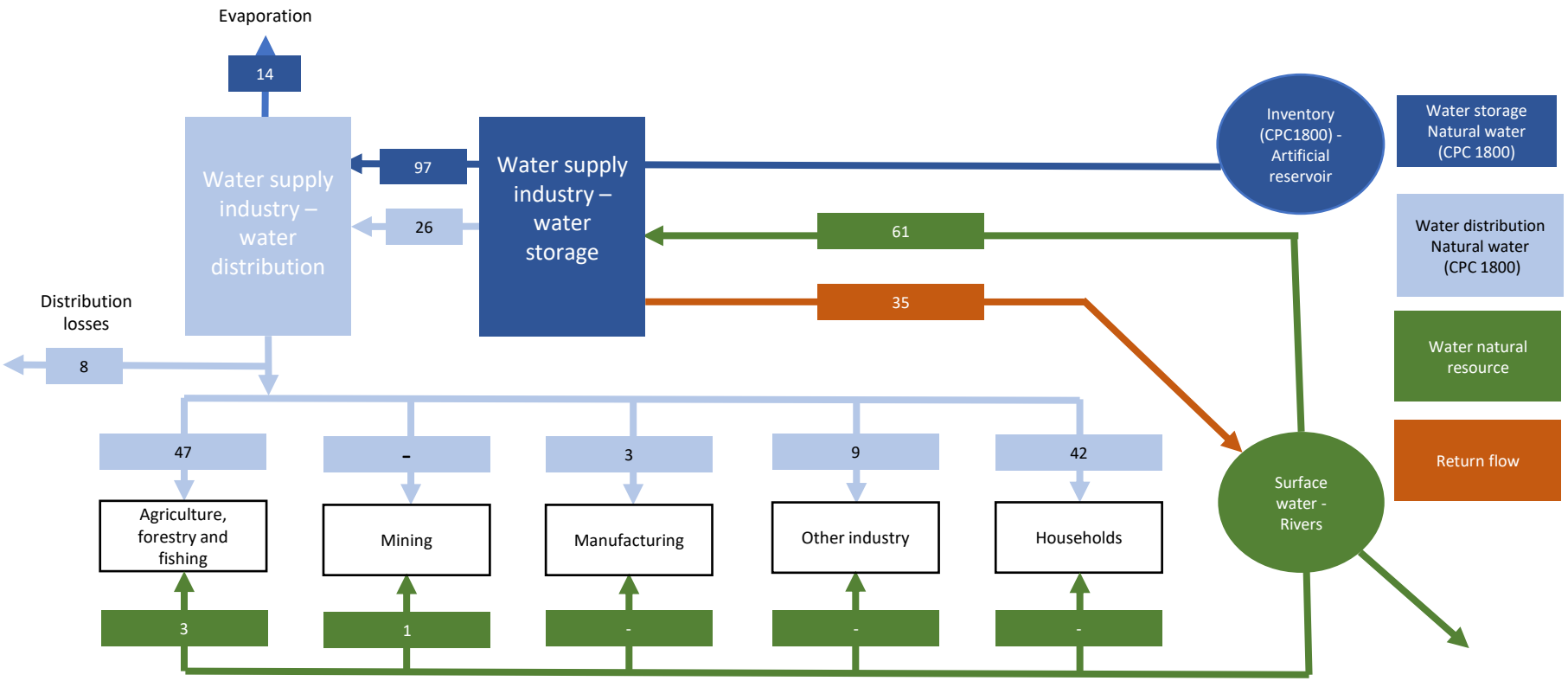
Reservoir water as a natural resource (non-produced asset), million m^3 – dry year



Current treatment, water in artificial reservoirs as a natural resource dry year, million m^3

		Economy								
Million m3		Agriculture, forestry and fishing	Mining	Manufacturing	Water supply	Other industry	Households	Import (supply) / Export (use)	Environment	Total
Supply										
Natural resouce										
	Artificial reservoirs								109	109
	Lakes								0	0
	Rivers								4	4
	Groundwater								0	0
	Total natural resource								*112*	*112*
Product										
	Natural water (CPC 1800)				109	production				**109**
Use										
Natural resouce										
	Artificial reservoirs				109					109
	Lakes									0
	Rivers	3	1							4
	Groundwater									0
	Total natural resource	*3*	*1*	*0*	*109*	*0*	*0*	*0*		*112*
Product										
	Natural water (CPC 1800)	47		3	8	9	42			**109**

Reservoir water as an inventory (produced asset), million m^3 – dry year

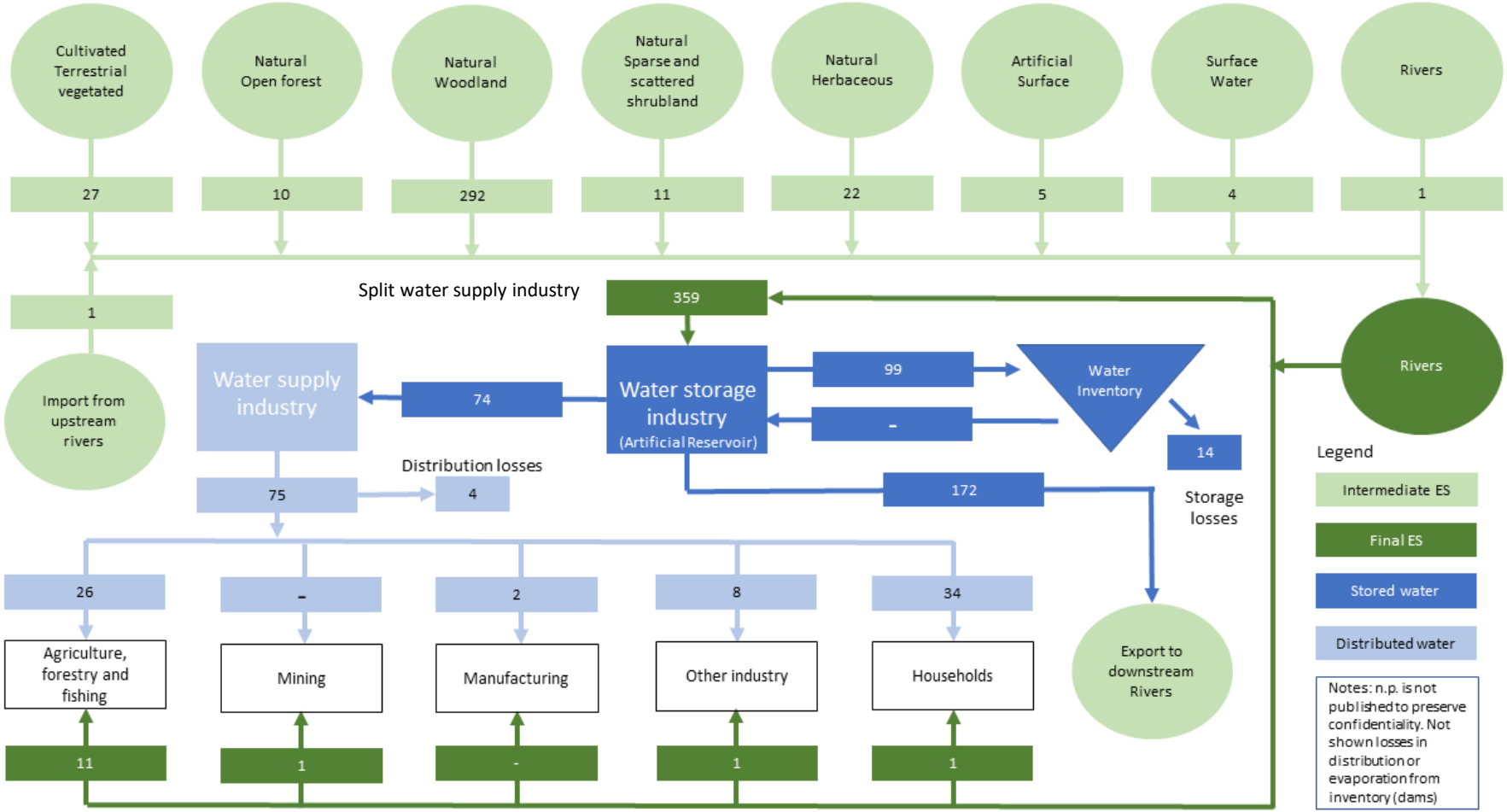


Proposed treatment, water as a natural resource, dry year, million m³

		Economy										
Million m3		Agriculture, forestry and fishing	Mining	Manufacturing	Water supply -storage	Water supply - distribution	Other industry	Households	Change in inventory	Import (supply) / Export (use)	Environment	Total
Supply												
Natural resouce												
	Lakes										0	0
	Rivers										65	65
	Groundwater										-	-
	Total natural resource											*65*
Product Natural water (CPC 1800)												
	Storage								97			97
	Distribution					26						26
	Total product	-	-	-	-	*26*	-	-	*97*	-		*123*
Return flow					35							35
Use												
Natural resouce												
	Lakes											
	Rivers	3	1		61		-	-				65
	Groundwater											
	Total natural resource	*3*	*1*	-	*61*	-	-	-	-	-		*65*
Product Natural water (CPC 1800)												
	Storage				14							14
	Distribution	47	-	3		8	9	42				109
	Total product	*47*	-	*3*	*14*	*8*	*9*	*42*	-	-		*123*
Return flow											35	35

A full treatment! Integrated SEEA CF and EA

Reservoir water as a produced asset (million m^3)



Reservoir water as a produced asset

ES or product		Units	Economy									Environment									Total
			Agriculture, forestry and fishing	Mining	Manufacturing	Water storage industry	Water distribution industry	Other industry	Households	Inventory	Import (supply) / Export (use)	Cultivated terrestrial Vegetated	Natural Open forest	Natural Woodland	Natural Sparse and scattered shrubland	Natural Herbaceous	Bare Surface	Surface Water	Rivers	Import (supply) / Export (use)	
Supply																					
Intermediate ES																					
	Water supply	million m3										27	10	292	11	22	5	4	1	1	**373**
Final ES																					
	Water supply	million m3																	373		**373**
Products																					
	Stored water	million m3				359															**359**
	Distributed water	million m3					74														**74**
Use																					
Intermediate ES																					
	Water supply	million m3																	373		**373**
Final ES																					
	Water supply	million m3	11	1		359		1	1												**373**
Products																					
	Stored water	million m3				14	74			99	172										**359**
	Distributed water	million m3	26		2		4	8	34												**74**

Losses from storage

Losses in distribution

Final ecosystem water supply service supplied to the water storage industry when it enters the reservoir (and to other industries and household when it is abstracted)

Recommendation 3. The water supply use tables in the Central Framework be updated to reflect reservoir water as a produced asset

Recommendation 4. That text is added to Central Framework clarifying treatment of water losses

Specific comments 1

Comment	Response
There is no need to change, as all the information is already covered in the existing water stock and flow accounts.	Agree that all the information is already included. However, the current accounting does not fully reflect the economic or environmental consequences of the water held in artificial reservoirs. The displacement of water in time and space, and the evaporation from reservoirs, has implications for the water supply industry and for economic units downstream of reservoirs. The information can be easily rearranged to better reflect the economic and environmental interactions. Note: Many agree that the change is warranted as it better reflects reality, the information is useful for water management and policy, and the issues to be solved are mostly practical.
Water cannot be produced because it does not come into existence via a production process.	Something does not have to come into existence for it to be produced. It just needs to be displaced in space or time by human activity. E.g. Iron Ore is in the ground as a natural resource and becomes a produced asset when it is extracted from the ground.
Need a clear definition of artificial reservoirs.	Maintain the current definition of artificial reservoirs and provide further guidance. Restrict scope to artificial reservoirs operated by the water supply industry (ISIC 36) with the primary purpose of storing water for supply to the economy (e.g., households, irrigation, hydroelectricity). Provide a size threshold and refer to World Register of Dams maintained by ICOLD.
Inclusion of small farm dams and rainwater tanks	Exclude these from the scope. Provide guidance on the treatment of own-account production by the agricultural and energy industries, as well as household and other rainwater tanks, for completeness and in circumstances where such information is important.
Establishing where artificial reservoirs begin and end (e.g., where does the river end and the reservoir begin)	Establish the start at the point where the water supply industry measures inflows to reservoirs. The reservoir ends at the dam wall.

Specific comments 2

Comment	Response
SUT has one column for the water supply industry (ISIC 36). A column labelled “artificial reservoirs”. Should be added. This make the link between water supply and the inventory clearer. “Inventory” should be “Change in inventory”	The suggestion to split is agreed but the columns should retain an industry classification. Previous SUTs presented to the LG split the water supply industry (ISIC 36) into water storage and water distribution, which was generally accepted, and that table will be used. This clarifies the links. Agree column should be “Change in inventory”. Clarification to be added in the text that the total inventory is not needed for the SUT and make link to the asset account
Concerns about data availability	All the data needed are included in the water asset account. Practically all water suppliers that operate large reservoirs monitor inflows and outflows.
Does the change have implications for the valuation of water?	A cross-cutting issue with D7 that needs to be coordinated. Groups have common members
Encouraged to engage with issue B2 Treatment of losses.	Connection made, yet to engage
Links to overlaps with SEEA EA	Noted. A combined SEEA-EA and SEEA-CF table was presented to the LG. Guidance needed on how best to engage with Issue A1 Links between SEEA-CF and SEEA-EA

Specific comments 3

Comment	Response
The change means the time of production changes, which affects GDP.	Make this clear in the text. As the water supply industry (ISIC 36) is a tiny fraction of GDP, national accountants will likely ignore. Does not change the timing of production of electricity production from hydropower.
Effect of calculation of depletion in the 2025 SNA	How water is accounted for in the calculation of depletion is a matter of SNA alignment. This issue extends beyond water in artificial reservoirs to all water resources. The change in the production boundary from water leaving the reservoir to water entering the reservoir would at least change the time of recording of depletion. Evaporation from artificial reservoirs would likely be recorded as depletion irrespective of the proposed change
More reference could be made to the change in the treatment of cultivated assets in the 2025 SNA	Noted. This is a general issue. The water guidance note and proposed text for SEEA CF will include appropriate references
What would a change in treatment mean for the definition of natural capital in the 2025 SNA?	Noted: The definition of natural capital is a general issue. For water, the treatment would likely be the same for cultivated and non-cultivated timber (i.e. include both as natural capital). The water guidance note, and proposed text for SEEA CF will include appropriate references.

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Produced asset

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- **The question is not whether it comes into existence , but when it is produced**

Production

- Production of reservoir water (natural water CPC 1800) is an activity carried out under the responsibility, control and management of an institutional unit (e.g., enterprises and establishments classified to Water Supply Industry ISIC 36), it uses inputs of labour (dam operation and maintenance), capital (e.g. dam walls), and goods and services (electricity, concrete, chemicals) to produce outputs of goods and services (i.e. natural water CPC 1800).

Produced boundary

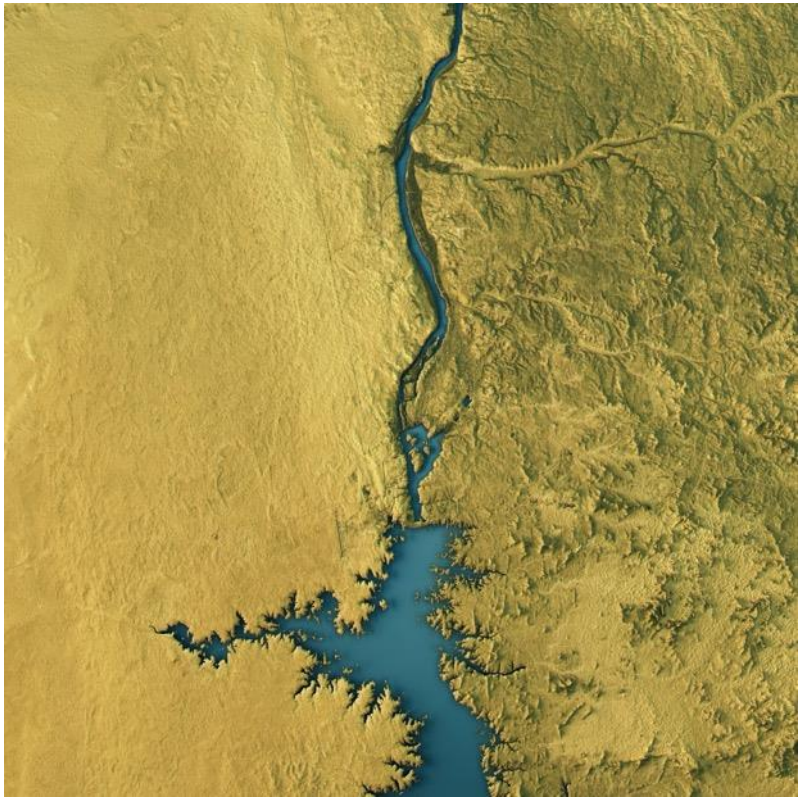
- Reservoir water is produced in the current period (inflow in current year) or in an earlier period (inflows from previous years) held in storage as an inventory for distribution
- Reservoir water may be distributed or stored for use at a later date

Conclusions

Slide of conclusions as presented to the 31st LG Meeting in Tallinn, Estonia, September 2025

Water in artificial reservoirs

- Aligns with the SNA definition of production, hence a produced asset (inventory)

Treatment

- Production occurs when water **enters** artificial reservoirs
- Record changes in inventory in PSUT
- Brings water into alignment with other natural resources (e.g. timber, fish and minerals)