System of Environmental Economic Accounting

Update of the SEEA Central Framework

Draft Guidance Note
Issue D.7

“Valuation of Water”

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v. 5.1 (Annex E fixed)

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Executive Summary

This note proposes a methodology for valuing water resources under the SEEA Central Framework, developed for Issue D.7 of the 2028 update. It is written for the Technical Committee and expert reviewers deciding whether this content should become part of the international standard, and for national statistical offices weighing what adopting it would mean for their own accounts. Nothing here is settled. Every recommendation is a proposal pending global consultation, not a compilation instruction.

Why this matters. Water accounts have uses well beyond national accounts integration. A river-basin-level monetary account tells a water ministry where scarcity is concentrated and what a drought would cost. It gives a finance ministry a basis for water pricing reform and for weighing infrastructure investment against other capital spending. It gives a statistics office a defensible number for water's contribution to output by sector. National accounts integration, specifically, valuing water depletion the way depletion of minerals or timber already is, is one application of this work, not the reason for it. SNA 2025 (paragraph 35.50) delegates natural resource depletion valuation to the SEEA CF update process, and water is the resource category that delegation left most unresolved; this note addresses that gap, but the accounts stand on their own regardless of how or whether the SNA link is eventually formalized.

Where things stand today. A handful of countries already compile some form of water account, among them the Netherlands, Australia, Mexico, Italy, Greece, China, the United Kingdom, Spain, and Canada. Their methods differ enough that stock and flow estimates aren't comparable across borders. No operational guidance currently resolves that. This note is a proposal to do so.

Three principles worth knowing before reading further. Water is valued as a resource, not a service: the aquifer or river is what gets valued, not a utility's revenue. Valuation is scarcity-driven: the same cubic meter is worth more in a stressed basin than an abundant one, and worth different amounts depending on use. And scope follows use, not physical form: an in-stream use like hydropower or thermal cooling counts if it carries an enforceable use right and a measurable economic benefit; a water body valued only for ecosystem services, with no use right attached, stays out of this account and belongs in SEEA Ecosystem Accounts instead.

What the note proposes. Section 4 sets out eight recommendations in full (Table 4.1). Four carry the most weight for whether and how a country would implement this:

- **A scope test for what counts as a water resource in scope of the account** (Recommendation 1), which the Technical Committee is specifically asked to weigh in on: does this test hold up against the SNA's economic-asset criteria in practice, or does it need further guidance (TC Question 5)?
- **A tiered valuation method**, market prices where observed, cost- or productivity-based estimation where they aren't, so a country with limited data has a defensible place to start rather than an all-or-nothing standard (Recommendations 4 and 5).
- **River-basin-level compilation** rather than national averages, since a single national figure hides exactly the scarcity variation the account exists to capture (Recommendation 6).

- **Water quality as a separate, documented adjustment to value**, not folded silently into volume (Recommendation 7). The Technical Committee is asked directly whether this should be a distinct degradation cost at all (TC Question 4).

Why this matters for economic statistics, and beyond. If adopted, these four changes let water enter NDP and national wealth accounting on the same footing as other natural resources, and let one country's water account be compared meaningfully against another's, which is not currently possible. They also stand independent of that adoption: a tiered method, basin-level compilation, and documented quality effects are useful to a statistical office producing water accounts for domestic water policy, with or without SNA integration. Six questions are open for formal Global Consultation before the 2028 update (§5.3); the four points above are where reviewer input will shape the recommendations most.

Questions for Global Consultation

Six questions (§5.3) are designated for formal global consultation before the 2028 SEEA CF update, alongside six further questions reserved for Technical Committee guidance (§5.4). Reviewers are asked to focus comments on the global consultation questions in particular; the full list appears in §5.3, §5.4, ahead of the annexes.

1. Introduction

1.1 Issue Description

1. This Guidance Note responds to issue D7 of the SEEA Central Framework (SEEA CF) update process: the valuation of water resources for inclusion in monetary asset accounts. The SEEA CF 2012 sets out the physical accounting framework for water in detail but treats monetary valuation only briefly, recommending net present value methods or market prices without specifying how to apply them to a resource whose depletion, unlike minerals or timber, depends on recharge as well as extraction. The issue identified for this note is closing that operational gap: giving compilers a workable method for moving from physical water accounts to a monetary asset account and a depletion charge.

2. In relation to water accounts, the SEEA 2025 Global Assessment of national statistical offices found that 38 countries report PSUT, 14 MSUT, and 17 physical asset accounts; monetary asset accounts were not captured, since the survey had no category for them. A separate review of all water accounts by Vardon et al. (2025) found only three countries with monetary asset accounts, attributing the low count in part to the technical difficulty and contested nature of water valuation.[1]

3. Monetary asset accounts for water resources (referred to here as water resource asset accounts) in the SEEA Central Framework require two components compiled jointly from a physical foundation. The physical supply-use table (PSUT), which will be described in Chapter 3 of the SEEA CF, records water flows (q_t) by source, user, and destination in volumetric units (m3). That table forces physical consistency before any price is applied and also captures own-account abstraction (direct self-supply) by agriculture, other industries and households that the standard monetary accounts do not typically record, a compilation gap rather than a conceptual exclusion: own-account production for a unit's own use is within the SNA production boundary.[2]

4. The second is the physical asset account, described in SEEA CF Chapter 5, which includes the categories surface water (artificial reservoirs, lakes, rivers and streams, glaciers, snow and ice), groundwater, and soil water. The asset account records, among other changes in stock, abstraction for human use which is equal to the amount supplied by the environment to the economy in the PSUT.

5. Monetary values follow from two inputs: the unit shadow price of water[3] and the abstraction volume. From these, the annual flow value, the stock asset value, and the depletion charge all follow by calculation. Guidance on estimating the shadow price is in §3.4; the derivation

[1] https://seea.un.org/sites/seea.un.org/files/files/Global_assessment/2025_GA/global_assessment_seea_25_for_website_0.xlsx

[2] Not because the accounts cannot in principle capture it (own-account abstraction should appear as a stock reduction in water resource asset accounts at constant prices) but because water balance sheets are rarely compiled and own-account abstraction goes unmetered (Fenichel et al., 2016).

[3] "Shadow price" here means the marginal in situ value of an additional unit of the water stock ($p^* = \partial V/\partial S$), not a term used in the SNA or general statistics. It is analogous to what national accountants might call a stock or asset unit price.

of stock value from the discount rate, and of the depletion charge from net recharge, is in §3.5 and §3.6; the treatment of near-exhaustion is in §4, Recommendation 8, and of zero-rent conditions in Recommendation 5; and the role of welfare estimates alongside exchange values is in §5.1.

Table 1.1: A note on terminology, economic valuation language vs. accounting terms

Term used in this note	Accounting-familiar equivalent	Note
Shadow price (p^*, $\bar{p}$)	Unit asset price / stock unit value	The marginal (p^*) or average ($\bar{p}$) value of one unit of the water stock. Not an SNA or SEEA CF term; borrowed from resource economics (see §1.1, footnote 3).
Resource rent (R)	Net operating surplus attributable to the resource	The return left over after deducting all other costs of production, including a normal return to produced capital, from the value of output.
Capitalization (NPV of a rent stream)	Income capitalization	Deriving an asset's value from the discounted stream of income it is expected to generate, the same logic used to value income-producing assets.
Depletion charge (D)	Depletion	The reduction in asset value from extracting more of the resource than is naturally replenished. Related to depletion allowances in extractive-industry accounting, though the SEEA CF version is a physical, volume-based deduction, not a tax provision.
Revaluation (REV)	Holding gain / loss	The change in asset value from a change in the unit price alone, holding the physical stock constant, the same concept as a holding gain on inventory.
Other changes in volume (OCV)	Other changes in the volume of assets	Already a standard SNA/SEEA CF category, not translated; included here for completeness.

6. This note uses the valuation-literature terms in the left column throughout, because they are the terms used in the primary sources (Fenichel, Obst and Wentland, 2024) and because the underlying concepts do not always map cleanly onto existing accounting categories. The

right-hand column is offered as a bridge for readers approaching this material from an accounting background, not as a substitute term.

1.2 Motivation

7. Water security is a growing global challenge. Freshwater demand has increased substantially over recent decades (driven by population growth, agricultural expansion, and urbanisation) while climate change is altering availability through shifting precipitation patterns, accelerated glacial loss, and more frequent drought. In many river basins and aquifer systems, abstraction is approaching or exceeding sustainable yield. Water pricing is among the most effective demand-management instruments available to governments: charges that reflect the scarcity value of water create efficiency incentives and signal the cost of competing uses. Sound monetary water resource accounts therefore serve two purposes: a statistical one, and a policy one, providing the evidence base for water pricing and sustainable water management policy.

8. The SEEA CF update mandated by the 55th Session of the United Nations Statistical Commission requires substantive guidance where the current SEEA CF 2012 provided only five paragraphs on water valuation (§5.11.4, paras. 5.488–5.492). The compilation pathway, from the physical PSUT to the monetary supply-use table to the asset account, requires detailed, operationally tested guidance that the 2012 framework did not supply. Describing solutions for closing this gap is the primary mandate for this note.

9. OECD's 2025 compilation guide, published to support national accountants implementing SNA 2025, reaches a different conclusion. It states that the valuation of depletion of water resources "is currently not recommended" under SNA 2025, and that any value changes should be recorded as other changes in volume rather than as a cost of production (OECD, 2025, §97). It then assigns the question to "the list of issues for the SEEA CF revision" and states it will not be "further discussed in this compilation guide" (OECD, 2025, §101). That deferral is what this note answers. Where OECD's guide treats the absence of an agreed method as a reason to record no value, this note supplies the method: a documented route from the SEEA CF's physical accounts to a monetary depletion charge, so that national accountants no longer have a basis for declining to compile one.

10. The SNA 2025 reclassification, which establishes depletion as a cost of production, provides a second impetus. This note extends that treatment explicitly to water, which the SNA does not separately address. Countries that have built water accounts under the SEEA CF can now supply the depletion charge needed to compile NDP, NNI, and net saving under the revised SNA. National balance sheets that omit water resources understate the natural capital position of water-dependent economies; NDP calculations that do not deduct water depletion overstate the income those economies generate.

11. Degradation faces the same gap. OECD's guide draws the depletion/degradation distinction by routing all water quality change to other changes in volume rather than to a cost of production, following 2025 SNA §13.32, and its own footnote concedes that the distinction itself "will be further discussed during the SEEA CF update process" (OECD, 2025, §203, fn. 38). No existing framework specifies how to price a degradation cost, when to separate it from depletion, or when a quality change crosses from natural variation into a monetary entry. §3.3.3 and Recommendation 7 answer that question for water: a degradation cost attributable to continuous anthropogenic quality loss, distinct from the natural or exceptional change that OECD's other-changes-in-volume treatment was designed for. As with depletion, the primary gap is not data but the absence of an agreed pricing procedure,

though data constraints remain real and separate for many countries; §3.3.3 and Recommendation 7 supply one.

1.3 Scope

12. This guidance note covers the valuation of water resources recorded under asset classification of the SEEA Central Framework (above) and the System of National Accounts, where this note proposes these SEEA CF categories map to the AN.34 water resources asset code, a mapping the SNA has not yet formally addressed for water specifically. The scope includes surface water (rivers, lakes, and reservoirs, pending resolution of GN D4 questions addressed in §5), groundwater, and potentially soil water. These are types of water resources included in the SEEA Central Framework physical asset accounts.

13. Out of scope: this note does not cover water supply infrastructure (pipes, treatment plants, distribution systems), or ecosystem services or the value of water to ecosystems (treated in the SEEA Ecosystem Accounts, UNSD et al., 2024). Section 3.1 gives the full statement of these exclusions alongside the productive in-stream uses that fall inside scope.

14. The note is organized as follows. Section 1 (Introduction) sets out the issue, motivation, scope, and relationship to SEEA CF, GN D4, and SNA 2025. Section 2 (Review of Existing Measurement and Research) surveys current accounting treatment and prior water valuation literature. Section 3 (Conceptual Options and Treatments) is the technical core: water resource typology and physical accounts, the monetary supply-use table, valuation methods, stock valuation, depletion and asset-account reconciliation, and SNA linkages. Section 4 (Recommendations on Conceptual Treatments) sets out the eight formal recommendations. Section 5 (Other Considerations in Advancing the Issue) covers welfare-value framing, research priorities, questions for global consultation, and issues requiring TC guidance.

15. Annexes A-E provide the interim stock-valuation approach, a classification concordance across frameworks, country case studies, the full mathematical framework, and worked numerical examples, respectively. Annex F extends the Annex D and Annex E framework to the SNA sequence of accounts, showing which SNA account, sector, and line a compiled water asset account populates. The compiler-facing language used throughout this note, including the technical core, the recommendations, and the annexes, should be read as a map of the note's argument, not as instructions to implement (see the Executive Summary for the note's overall status pending global consultation).

1.4 Relationship to SEEA CF, GN D4, and SNA 2025

16. The SEEA Central Framework (2012[4]) includes an asset account for water resources with the classification provided above, and notes that they may be valued using discounted resource rent (paras 5.490 and 5.491) or the value of water access entitlements (para. 5.492). This note operationalizes the resource rent approach. It draws on the physical

[4] Adopted by the UN Statistical Commission at its 43rd session (2012); published 2014. The 1993 SNA first established the principle of recording natural resources as assets; the SEEA CF 2012 operationalized this framework specifically for water and other environmental assets.

accounting framework in Chapter 3 of the SEEA CF and extends it to a monetary equivalent of the tables described in Chapter 5.

17. GN D4 covers the treatment of water in artificial reservoirs and was the subject of global consultation earlier in 2026. The feedback from that process showed good support for treating water in large artificial reservoirs as a produced asset and also for the recording of the depletion of water resources. That produced-asset treatment is not yet adopted: pending a final decision, Table 2.1 and this Guidance Note continue to classify reservoir water under AN.34 as the current baseline. §3.8 describes the current interface and the GC Questions that remain open.

18. The SNA 2025 revision alters the asset boundary to include renewable energy resources under a new classification AN.32. Hydroelectric resources are addressed in that discussion and create interface questions with GN D7 that §3.8 also describes.

2. Review of Existing Measurement and Research

2.1 Current Accounting Treatment in the SEEA CF

19. Surface water and groundwater are classified as natural resources under AN.34 in the SNA 2025 §11.11(c) while the SEEA CF 2012 asset account uses a different but related classification. This Guidance Note follows the SEEA CF classification in the physical asset account and refers to this as water resource assets throughout. Water resources are classified, per SEEA CF Table 5.24 (§5.11.2), as categories 1 (surface water, with four subclasses), 2 (groundwater), and 3 (soil water) in the SEEA CF physical and monetary asset accounts. Classes 1 and 2 correspond to asset code AN.34 in the SNA 2025 balance sheet; soil water (class 3) does not. Throughout this document, AN.34 is used when referring specifically to the SNA monetary balance sheet entry; SEEA CF Table 5.24 subclass codes are used alongside resource-type names where classification specificity is required.

20. Water resources enter the economic asset boundary when two conditions hold: abstraction rights or in-stream use rights are legally enforceable (or otherwise recognised as conferring economic ownership), and the resource generates or is expected to generate economic benefits to its owner. The owner may manage the resource on behalf of others, including entire communities (SNA 2025 §1.68, p. 32). In-stream uses (hydropower generation, thermal cooling, and canal operation) satisfy both conditions where use rights are defined and the water is a critical productive input; they accordingly fall within the scope of monetary asset accounts in the SEEA CF (see §3.8).

21. Whether the "enforceable" condition above is satisfied, and what it means for a right to be enforceable, is not a fixed, universal fact about water: it is set by the institutional and legal regime governing allocation in a given jurisdiction, and that regime varies as much within countries as across them. The United States illustrates this within a single federal system: Eastern states generally follow riparian doctrine, where the right to use water attaches to land bordering the resource, is not quantified as a fixed volume, and historically cannot be sold separately from that land; Western states generally follow prior appropriation, where rights are quantified, dated by priority, and, in many states, transferable independent of land ownership.

22. The same underlying resource, under two different institutional regimes, produces materially different answers to the accounting question: a prior-appropriation right is a defined, often-transferable claim that can support a market price (§3.4.2); a riparian right is not typically transacted at all, which affects not only which valuation tier is available but whether "enforceable use right" in the sense Recommendation 1 requires is even a well-defined test to apply.

23. This is a specific case of the broader common-pool resource problem: water is rivalrous but often difficult to exclude others from, and how a jurisdiction resolves that, through private rights, permitting, communal management, or some mix, determines whether resource rent is capturable and measurable at all, not merely how it should be priced once captured. §3.4 returns to the consequence for method choice; §5.4 sets out the open question this raises for the note more broadly.

24. A classification boundary arises with some hydroelectric resources, following the SNA 2025 removal of the AN.2 licence category for natural-resource permits (OECD, 2025, Measuring Natural Resources in the National Accounts: A Compilation Guide, fn. 42). The classification boundary for hydroelectric resources is therefore between AN.34 (water resources) and AN.32 (energy generation resources), not AN.2. §3.8 describes this boundary and its accounting consequences in detail.

25. Monetary valuation of water resources is addressed in only five paragraphs of the SEEA CF 2012 (§5.11.4, paras. 5.488–5.492) and in Chapter VIII of SEEA-Water (UNSD et al., 2012). Together they constitute the full body of current formal guidance on monetary water valuation. Both documents recommend net present value methods or market prices but neither provides an operational method: they do not specify how to move from an observed price to a shadow price, how to construct the monetary supply-use table, how to reconcile MSUT and asset-account valuations, how to calculate depletion, or how to treat periods when abstraction falls below natural recharge. This Guidance Note is intended to provide proposals that more fully support implementation of monetary values for water resources.

2.2 Links to Other Frameworks and Issues

26. The SNA 2025 changes have direct implications for this issue. Under the revised framework, the depletion of natural resources is a cost of production, reducing NDP in the period it occurs. SNA 2025 paragraph 35.50 delegates guidance on natural resource depletion valuation generally to the SEEA CF update process. This note extends that general delegation specifically to water, for which the SNA does not provide separate treatment, making it the primary reference for water depletion methodology pending SNA engagement on this point.

27. The SEEA CF records the resource rent on abstracted volumes; the SEEA EA records the provisioning service value of the same water supply from an ecosystem accounting perspective. The two accounts are not mutually exclusive but have different accounting boundaries: the SEEA CF operates within the SNA production boundary; the SEEA EA can additionally record ecosystem services outside that boundary, including non-market uses (e.g. recreational or aesthetic in-stream values).

28. For water entering production within the SNA boundary, whether transacted in a market or self-supplied for own-account use, the exchange-value measure of the SEEA EA provisioning service is the resource rent; the two accounts record the same quantity, not additional components to be summed. Where both accounts are compiled, the non-double-

counting rule is a presentation rule: CF and EA values must not be summed into a single income or wealth aggregate, because they share the same physical water flows. They should be reported in parallel with metadata explaining what each measures, and a bridge table linking them is recommended (§5.1). The EA may record a larger value than the CF rent where it additionally captures provisioning services outside the SNA boundary; it will record the same value where it is limited to exchange-value-compatible methods for market uses.

29. SEEA-Water (UNSD et al., 2012), Chapter VIII, provides the most detailed existing discussion of water valuation in a SEEA context. It surveys techniques and considers country applications but makes no method recommendation. Four further SEEA CF update issues require coordination with GN D7: Issue D1 (carbon stock account), Issue A1 (SEEA CF and SEEA EA links), Issue A4 (spatial explicitness of SEEA CF accounts), and Issue A9 (consistency with SNA 2025). The resolution of each has implications for how this note's proposals should be read.

2.3 Water Resource Typologies

30. Valuing water requires physically knowing what kind of water is being valued, as each resource type has distinct physical characteristics affecting how valuation proceeds. Surface water (§5.11.2, Table 5.24: code 1) in rivers (code 1.3), lakes (code 1.2), and artificial reservoirs (code 1.1) is a renewable stock replenished by precipitation, snowmelt, and upstream inflows. Groundwater (code 2) spans a spectrum from renewable unconfined aquifers with measurable annual recharge to fossil confined aquifers with effectively zero recharge on human timescales, with an intermediate case of semi-confined aquifers with slow, measurable recharge; §3.1.2 sets out the resulting three-way distinction and its implications for depletion measurement.

31. The boundary treatment of soil water (code 3) and glacier resources (code 1.4) in monetary accounts is an open question; §3.1.3 describes the current state and the GC Questions on which direction is sought. Table 2.1 maps these typologies against the accounting treatment each implies.

Table 2.1 Water resource typologies and accounting treatment.

Each water resource type is mapped against its SEEA CF asset classification, monetary account status, and valuation approach. Green shading indicates resources in scope for AN.34 monetary accounts under current guidance; amber indicates boundary cases subject to TC recommendations and global consultation; grey indicates resources currently out of scope or not yet classified. Resource types marked with a GC question letter are the subject of formal consultation questions in §5.3. The warning symbol (⚠) flags the fossil (confined) groundwater row, where the standard perpetuity formula V=F/r must not be used; compilers should instead apply the finite-horizon NPV formula (§3.1.2, §3.6.1).

Resource Type	SEEA CF Code	SNA 2025 (AN.34 status)	Status	Valuation Approach
Surface water: rivers & streams ● Renewable	1.3	AN.34	In scope (§3.1.1)	Resource rent; Harberger p̄=V/S D=p̄×(q−g). Stock=sustained yie
Surface water: lakes & artificial reservoirs ● Renewable	1.1, 1.2	AN.34	In scope (§3.1.1)	Resource rent; Harberger p̄=V/S D=p̄×(q−g). Reservoir water also with GN D4 (§3.8.1).
Groundwater: renewable (unconfined) ● Renewable	2	AN.34	In scope (§3.1.2)	Resource rent; Harberger p̄=V/S D=p̄×(q−g).
Groundwater: semi-confined (intermediate recharge) ● Renewable (slow)	2	AN.34	In scope: special (§2.3)	Resource rent; discount horizon to actual recharge timescale (§2 between perpetuity and fossil fin
Groundwater: fossil (confined) ● Non-renewable	2	AN.34	In scope (§3.1.2) ⚠	Resource rent; finite NPV requir Harberger p̄=V/S; D=p̄×q (g≈0).
Soil water ● GC Question (b)	3	Not in AN.34 (embedded in land)	Boundary: GC pending (§3.1.3)	No agreed method; value stays in the land asset unless reclassi
Glaciers & ice sheets ● GC Question (c)	1.4	No AN.34 guidance yet	Boundary: GC pending (§3.1.3)	No agreed method; ownership/c open. Physical tracking still mea without a monetary boundary.

2.4 Existing Research and Measurement

32. The primary synthesis references are Vardon, Oleson, and May (2024), a review of accounting for water presented to the 2024 London Group meeting, and Vardon et al. (2025), a global review of water accounting that proposes indicators of best practice for improved water governance. Meurer and van Bellen (2024) provide a complementary global comparative analysis assessing 13 countries' water accounts against the SEEA Water framework, finding high adherence to physical supply-use tables but limited progress on asset accounts. Together these reviews survey physical and monetary water accounts across countries, identify specific recommendations for the SEEA CF update, and provide the principal literature basis for the recommendations in §4.

33. The critical finding in the existing literature is the absence of any official national-accounts study that successfully bridges from an annual flow value F_t to a balance sheet asset value V using a defensible discount rate and sustainable extraction rate (Reas et al., forthcoming). Research implementations (notably Fenichel et al. (2016) for High Plains groundwater) have demonstrated the approach. Not one of the country implementations reviewed by Vardon, Oleson and May (2024) has published a water resource balance sheet entry derived from a formal NPV projection of future resource rents. Annex A proposes an interim approach.

34. Country-level implementations provide the most directly accounting-relevant evidence. The Netherlands (Edens and Graveland, 2014) and Australia (Vardon, Keith, and Lindenmayer, 2019; Chen et al., 2025) have the most developed SEEA-scoped water accounts; the Murray-Darling Basin provides the most developed functioning water market globally (Walsh, 2021), with publicly reported transaction prices that offer Tier 1 exchange value observations of water flows (Grafton et al., 2012; de Bonviller et al., 2019; Wheeler, 2022). Annex C surveys these and nine further country implementations in detail.

3. Conceptual Options and Treatments

3.1 Water Resources: Scope and Typology

35. Water resources are classified as non-produced natural resources (AN.34) in the SNA. This note adopts the SEEA CF classification as primary; the correspondence with the SNA's AN.34 category is addressed separately, in §3.8 and Recommendation 1. The SEEA CF (§5.11.2; Table 5.24) uses a related but extended asset classification, organized into the same three categories (surface water, groundwater, soil water) as the physical asset account in Table 5.25, reproduced in Figure 3.1. The SEEA CF establishes the asset boundary and the physical accounting framework; the System of Environmental-Economic Accounting for Water (SEEA-Water, UNSD et al., 2012) provides supplementary guidance on physical classifications, supply-use tables, and quality accounts. This section describes the scope of water resources covered by this Guidance Note under each typology and notes where the two frameworks are silent or inconsistent.

Table 5.25
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

Note: Dark grey cells are null by definition.

Figure 3.1. Table 5.25 from SEEA CF, physical asset account for water resources

36. The note does not cover water supply infrastructure (pipes, treatment plants, distribution systems). It does not address ecosystem services outside the SNA boundaries or the value of water to ecosystems, which are treated in the SEEA Ecosystem Accounts (UNSD et al., 2024). It does not provide guidance on water pricing policy. Productive in-stream uses (hydropower generation, thermal cooling, and canal operation) are separately identified in the SEEA-CF asset account. The interface with GN D4 on reservoir water, the treatment of return flows, and the AN.32 renewable energy boundary are addressed in §3.8.

3.1.1 Surface water (§5.11.2, Table 5.24: code 1)

37. Surface water (code 1) includes artificial reservoirs (code 1.1), rivers and streams (code 1.3), lakes (code 1.2), and glaciers and ice (code 1.4). Note that some of the same physical flows recorded here as surface water abstractions in SEEA-CF accounts may also appear as ecosystem service contributions in SEEA-EA accounts; the two frameworks apply different labels to what is physically the same water transfer (Chen et al., 2025). By interpretation of SEEA CF (§5.2.3, paras. 5.31–5.33), inland surface water qualifies for monetary valuation when the general economic asset boundary conditions are met, i.e., an economic owner can enforce access rights and the resource is expected to provide future economic benefits. Renewable surface water bodies are recharged continuously through precipitation, snowmelt, and groundwater discharge. Accounting periods for renewable systems are annual; the closing stock reflects the balance between natural recharge and extraction during the year.

38. The concept of stock depletion applies differently to flowing surface water than to groundwater. For a renewable unconfined aquifer, unextracted recharge accumulates physically as a stock increase. For a flowing river without storage infrastructure or lakes, unextracted inflow exits the accounting territory as downstream flow and cannot be carried forward. A volume of water is nonetheless physically present in the reach at any moment; it is simply not an accumulating balance-sheet stock, since without storage it is in transit and will have moved downstream by the next accounting date.

39. In the context of measuring depletion, the "stock" of a flowing river is better understood as its sustained yield capacity: the present value of the perpetual rent stream generated by the share of long-run average annual inflow that can be extracted without reducing the river's future capacity to generate that stream; this sustainable share is necessarily below total average inflow, since some portion must remain in-stream to sustain baseflow and minimum environmental flows. Depletion of a river asset does not mean a reduction in inflow itself, which is set by upstream and climatic conditions rather than by extraction; it means reducing that sustained yield capacity, the resource's capacity to keep generating income under stress, which is also a basic indicator of the basin's hydrological and economic resilience, through progressive over-extraction that lowers baseflow, draws down connected alluvial groundwater, or degrades minimum environmental flows below which the system loses ecological and economic viability.

40. For accounting purposes, the depletion charge $D = \bar{p} \times (q_t - g_t)$, where g_t = natural recharge (defined in §3.2.3), is valid when $q_t > g_t$ on an annual basis, but compilers should note in metadata that for most perennial rivers without storage, sustained $q_t > g_t$ is physically constrained; depletion risk more commonly manifests as seasonal exceedance or alluvial groundwater drawdown, which may require sub-annual data or a connected groundwater account to measure accurately.

41. Lakes (code 1.2) and reservoirs (code 1.1) present different problems. Both impound surface water run-off and rivers flow into them. Lakes are a natural feature, and their volume grows or shrinks with climatic conditions, natural outflows, and extractions for use. Reservoirs behave similarly but present a different question. Water stored in a reservoir behind a dam is physically a water resource. SEEA CF §5.11.2, para. 5.478 and SEEA-Water §VI.C.2, para. 6.23 do not resolve whether reservoir waters should be recorded separately from lakes, although they are included in the physical asset account (Table 5.25). GC Question (a) asks countries to report their current practice on whether reservoir waters are recorded separately from lakes in the physical asset account. This is a classification and recording-practice question, not the produced/non-produced asset boundary question addressed elsewhere in this note. §3.8 describes the competing options and their accounting consequences.

3.1.2 Groundwater (§5.11.2, Table 5.24: code 2)

42. Groundwater is covered in SEEA CF §5.11.2, para. 5.479 and SEEA-Water §VI.C.2, para. 6.16. The SEEA CF notes that groundwater is recorded in AN.34 when economically exploitable and subject to ownership or control; it does not differentiate aquifer types for valuation purposes. This Guidance Note distinguishes three situations with different implications for depletion measurement. Unconfined aquifers connected to surface recharge behave like surface water: the stock is replenished each year, and depletion arises only when extraction exceeds recharge. Semi-confined aquifers with measurable but slow, intermediate recharge (Table 2.1) occupy a middle category where extraction can exceed sustainable yield without permanent depletion if managed carefully. Fossil, confined aquifers

with effectively zero natural recharge on human timescales present the clearest depletion case: any extraction reduces the stock permanently.

43. The Ogallala Aquifer in the United States and the Nubian Sandstone Aquifer System in North Africa represent the two best-documented large-scale fossil systems globally (Filippelli et al., 2022; Bakhbakhi, 2006). Structural evaluations demonstrate that their current extractions draw almost exclusively from non-renewable paleowater reserves trapped during past pluvial periods, operating entirely outside the modern hydrological cycle (Gutentag et al., 1984; Heinl and Brinkmann, 1989; Thorweihe and Heinl, 2002). §3.6.1 sets out the general fossil-aquifer depletion treatment ($g_t \approx 0$) that these systems exemplify. The key distinction for compilers is whether a recharge rate g_t can be estimated for the accounting period. Where $g_t \approx 0$, all extraction counts as depletion; where g_t is measurable, depletion applies only to extraction above that rate.

3.1.3 Soil water (§5.11.2, Table 5.24: code 3) and glaciers (code 1.4)

44. Soil water (code 3) and glaciers (code 1.4) raise boundary questions for valuation. SEEA CF §5.11.2, para. 5.480 defines soil water as water suspended in the uppermost belt of soil and includes it as a standard column in its physical asset account (Table 5.25, §5.11.3, paras. 5.481–5.485), though it flags that the stock is difficult to measure and its scope is often limited in practice. SEEA-Water §VI.C.2, para. 6.13 places soil water in its own asset classification (EA.133) but notes that water management in practice tends to neglect it relative to surface water. Neither source ties this physical-accounting treatment to a monetary asset boundary: soil water is not separately identified in AN.34, and it is not abstracted in a way that can be metered or priced.

45. Soil water nonetheless supports agricultural production directly, and its exclusion means that the contribution of soil moisture to crop output is not captured in monetary accounts (Chen et al., 2025). Soil water can only be accessed through land (for example, via rain-fed crops) and cannot be transacted separately from the land parcel it relates to, so its value is already captured in the land asset regardless of how SEEA CF classifies it; this is not in doubt, and SNA 2008 draws the same land-embedding conclusion. The question here is a SEEA CF classification question, not a valuation question: whether SEEA CF should separately identify that embedded value as a distinct water resource asset.

46. The conceptual basis for separately identifying some soil water stocks as a distinct SEEA CF asset, rather than leaving their value embedded in land, was explored in the London Group (Comisari and Vardon, 2013), which proposed a framework for distinguishing economically accessible water stocks from the broader hydrological reserve. That paper remains the primary reference for boundary questions that the SEEA CF 2012 left unresolved, and the GC Questions in §5.3 draw directly on the distinctions it introduced.

47. Leaving soil water unclassified as a separate SEEA CF asset carries no double-counting risk under current practice, since soil water is not separately valued and its contribution stays embedded in the land asset; a country that later classifies soil water as a standalone SEEA CF water resource asset would need to net out that component from land valuation to avoid counting it twice. For scope, this note treats rain-fed and supplementally-irrigated agricultural land as the relevant boundary case: soil water beneath such land is not separately identified as a distinct SEEA CF asset pending resolution of this classification question.

48. A comprehensive review of national implementation experience is provided in Vardon, Oleson and May (2024), which documents current practice on boundary treatment (including soil water and glaciers) across a sample of SEEA-implementing countries and identifies the gap between the AN.34 boundary as specified and as actually compiled as a priority issue for the 2028 update.

49. Notably, the World Bank's recent feasibility assessment for including water in the Changing Wealth of Nations treats soil water as a distinct asset category alongside surface water and groundwater, indicating that the boundary question is live in broader natural capital accounting contexts beyond AN.34 (Vardon, 2024). Any decision to include soil water in AN.34 would require resolving this land–water asset boundary within the SNA 2025 framework as well as establishing physical measurement methods.

50. Glaciers and permanent snowpack are classified under SEEA CF Table 5.24 (surface water, code 1.4) but are not addressed in the specific water accounting guidance at §5.11.4, paras. 5.488–5.492, and SEEA Water is similarly silent. They constitute a freshwater stock whose depletion has measurable downstream consequences for river systems and groundwater recharge, but no agreed valuation method exists and current accounting practice does not include them. Physical depletion, measured as volume loss, remains a meaningful indicator for both resources even where they cannot satisfy the SNA criteria for a recognized economic asset, since a monetary valuation is not a precondition for tracking physical stock decline. Glacier melt driven by climate change can present a particular measurement risk: rising downstream flows may read as an increase in freshwater stocks and flows appearing from nowhere, when the physical reality is drawdown of a finite stock trapped in ice. Global glacier mass balance has been negative and accelerating since at least 2000, with observed thinning rates roughly doubling over the past two decades (Hugonnet et al., 2021); this Guidance Note accordingly treats glaciers as functionally non-renewable (§3.1.2, §3.6.1) rather than as a recharging stock. Treating glaciers as out of scope risks missing this depletion entirely.

51. Both boundary questions remain open for this note (GC Questions (b) and (c), §5.3).

3.2 Physical Water Accounts: The PSUT as Foundation

3.2.1 Structure of the physical supply-use table

52. The physical supply-use table (PSUT) records water flows by source, user, and destination in volumetric units, typically millions of cubic meters per year. Supply columns record water entering the economy from each source: surface water abstraction, groundwater abstraction, precipitation directly captured, and water returned to the economy through treatment and re-use. Use columns record water by sector of use: agriculture (ISIC A), industry (ISIC B–E), households, and the rest of the world. Total supply from all sources equals total use by all users plus net environmental flows. The table balances itself; if it does not, the source data contain an error.

53. The PSUT's value as a foundation for monetary accounts is that it forces physical consistency before any price is estimated. A monetary account built without a reconciled physical table can misallocate abstraction volumes across sectors, creating systematic error in the depletion charge. Throughout this Guidance Note, monetary values are expressed in International dollars (Int$), a hypothetical currency unit that equalises purchasing power across countries, enabling cross-country comparison of resource rent and asset values

without distortion from nominal exchange rate fluctuations. The accounting relationships are currency-invariant.

54. The table includes own-account abstractors. Agriculture, mining, and manufacturing operations that abstract directly from rivers or aquifers, treat the water on-site, and use it in production have no transaction to record in the accounts as typically compiled. Their abstraction volumes are a physical input to production, not a financial one. The PSUT captures these flows; compiled monetary accounts typically do not, not because the SNA excludes own-account production but because it goes unmetered and unvalued in practice. This is the origin of the own-account abstraction gap described in §3.3.2. In principle, own-account water use is a genuine productive input under the SNA boundary regardless of whether it is metered: the gap described here is a data-availability problem, not a conceptual exclusion, and compilers with credible estimation methods (e.g. remote sensing, crop-water models) should value it rather than treat its absence from standard accounts as definitive.

3.2.2 River basin accounts as the compilation unit

55. Water follows watersheds, not administrative boundaries. A river basin may cross several countries; a coastal aquifer may underlie urban, agricultural, and protected areas with competing claims. Building accounts at the national level and disaggregating at a finer scale later creates a spatial averaging problem (discussed further in §3.5.3): national totals conceal variation in scarcity across basins, and national average prices carry no spatial information useful for allocation decisions.

56. Following the SEEA CF 2012 (para 5.494) the preferred compilation architecture starts at the river basin. Each river basin produces its own PSUT, its own asset account, and its own price estimate. National totals aggregate from river basin accounts rather than serving as the primary compilation unit: physical stocks and flows sum directly across basins, and where a national price is reported it is a volume-weighted average of basin-level $\bar{p}$ values, not a simple mean across basins, so that larger basins appropriately dominate the national figure. More generally, any variable reported as a national mean across basins (the price $\bar{p}$, the q_t/g_t sustainability ratio, or otherwise) should be accompanied by the standard deviation of that mean across basin-level values, so that spatial variability is not lost in the national aggregate. Australia's National Water Account applies this architecture across 13 river basins, with separate physical and monetary statements for each basin reported annually (Bureau of Meteorology, 2024b).

3.2.3 The physical asset account

57. The physical asset account (Table 3.1) tracks the water stock from one period to the next:

$$S_{t+1} = S_t + g_t - q_t \pm OCV_t$$

58. where S_t is the opening physical stock (volume), g_t is net natural recharge (additions from precipitation, inflows from other territories, and inflows from other inland water resources, minus natural losses such as evapotranspiration and, for stored resources, natural outflow independent of extraction, for example spillway release from a full reservoir; for unstored river systems, unextracted inflow is not netted into g_t but is instead recorded as an other-changes-in-volume outflow, per §3.6.3), q_t is total abstraction (reductions). g_t is derived from Table 3.1's own Precipitation, Inflows, and Evaporation/Actual evapotranspiration rows; it is not equivalent to Table 3.1's Increases-in-stocks subtotal, which is not netted for evaporation. Following the SEEA CF's own additions-and-reductions typology for the

physical asset account (rather than an imported SNA classification of flows) recharge and abstraction are reported as additions and reductions respectively, distinct from the other changes in volume category, so that the additions and reductions rows in Table 3.1 remain interpretable in their own right. The balance identity holds by construction.

59. This physical-account "other changes in volume" row is distinct from the monetary asset-account OCV balancing item introduced in §3.6.3 and Annex D, which reconciles a different pair of quantities; the two should not be conflated. Note also that depletion is not read directly from Table 3.1: the ratio q_t/g_t in §3.2.3 identifies whether extraction exceeds recharge, but the monetary depletion charge D_t (§3.6, eq. D.5) requires net abstraction $q_{t,net}$ (defined below, para 66), the explicit sustainable-yield benchmark g_t, defined in this section, and the shadow price $\bar{p}$, defined in §3.5.

Table 3.1: SEEA-Water Standard Table XII, Water Resource Physical Asset Account (physical units)

	Surface water				Groundwater	
	Artificial reservoirs	Lakes	Rivers & streams	Snow, Ice & Glaciers	Renew-able	Confin (slow recharg
Opening Stocks						
Increases in stocks						
Returns from the economy						
Precipitation						
Inflows						
From upstream territories						
From other resources in the territory						
Decreases in stocks						
Abstraction						
Evaporation/Actual evapotranspiration						
Outflows						
To downstream territories						
To the sea						
To other resources in the territory						
Other changes in volume						
Closing Stocks						

60. The ratio q_t/g_t summarizes the sustainability condition. For stored resources (aquifers, reservoirs), where $q_t/g_t > 1$ consistently, the resource is being drawn down and will eventually be physically exhausted. For unstored river systems, which hold no accumulating stock to exhaust (§3.1.1, paras 38–39), the same sustained condition instead erodes the river's sustained-yield capacity, its ability to keep generating income under stress, without implying the river itself runs dry. This ratio should be reported alongside the stock account as a basic sustainability indicator. Consistent with the river-basin compilation architecture in §3.2.2, this ratio is computed per river basin, not nationally; a national figure aggregated across basins with different hydrological conditions would obscure exactly the kind of local depletion this indicator is meant to flag.

61. A single year of $q_t/g_t > 1$ can reflect annual noise rather than sustained depletion. Compilers should report the ratio both for the current year and as a multi-year moving average (three to five years, depending on hydrological variability), and should treat sustained multi-year drawdown, not a single year's reading, as the basis for a depletion determination. Consistent with §3.2.2, a national q_t/g_t summary should be reported together with its standard deviation across basins. For fossil aquifers, $g_t \approx 0$ by definition, so the ratio is undefined, but the sustainability condition is unambiguous: any extraction is depletion.

62. **Managed aquifer recharge and return flows.** Some countries operate managed aquifer recharge (MAR) programmes that inject water (sourced from surface water, treated wastewater, or inter-basin transfers) directly into an aquifer to augment stock beyond natural recharge. MAR is a deliberate, recurring, human-directed addition, not the unexpected or non-recurrent change that Other Changes in Volume is reserved for in the SEEA-Water standard (reclassifications, stock-estimate revisions, catastrophic losses); it belongs instead in Table 3.1's existing Increases-in-stocks rows. Compilers should record MAR sourced from treated wastewater or inter-basin transfer as a tagged sub-line of Returns from the economy, and MAR sourced from surface-water diversion as a tagged sub-line of Inflows, distinguishing it from the untagged (natural) entries in the same rows. The stock identity becomes: $S_{t+1} = S_t + g_t + i_t$,MAR − $q_t \pm OCV_t$, where i_t,MAR is the MAR volume injected during period t, recorded in its tagged sub-line rather than in g_t or OCV_t. The depletion charge formula (§3.6, eq. D.5) uses natural recharge g_t only; MAR does not reduce depletion because it involves a produced input (energy, infrastructure, sourced water) external to the aquifer's natural renewal cycle. Tagging MAR within its proper Increases-in-stocks row, rather than folding it into g_t or misusing OCV, keeps the physical account standard-consistent while ensuring the natural recharge parameter g_t remains uncontaminated by managed flows, preserving comparability of the sustainability indicator q_t/g_t across countries and over time.

63. **Temporal variability of recharge.** Natural recharge g_t can vary substantially from year to year, driven by precipitation cycles, seasonal snowmelt, and inter-annual climate variability, even when abstraction q_t remains relatively constant. This creates a methodological question: should compilers accept positive depletion charges in dry years and zero (or negative) charges in wet years, or should recharge be smoothed across periods?

64. The recommended approach is: (a) compile accounts annually using the observed g_t for each period and report the resulting D_t without suppressing year-on-year sign changes. This is the primary, policy-relevant series; (b) report a supplementary multi-year average depletion charge using a rolling average of g_t over a climatologically representative window (typically 5–10 years, or one full precipitation cycle where data permit), alongside the primary annual series.

65. A positive depletion charge in one year followed by zero depletion the next is not necessarily a compilation error; it may accurately reflect hydrological reality. Compilers should document the temporal pattern of g_t in metadata and flag accounts where inter-annual variability in recharge is the dominant driver of the depletion charge.

66. Agricultural return flows (the fraction of q_t that infiltrates back to the aquifer or surface body after irrigation) are likewise recorded as a separate inflow in the physical account rather than deducted from gross abstraction q_t. The convention that q_t represents gross abstraction ensures that full extraction volumes are transparent in the PSUT. Where an irrigation scheme is required to recycle a share of q_t back to the source reservoir, that mandated return re-enters the physical account as an inflow in the same period, alongside voluntary return flows. Depletion is assessed against net effect: gross abstraction stays fully visible in the PSUT, but the depletion charge (§3.6, eq. D.5) is computed on $q_{t,net}$, abstraction net of both mandated and voluntary returns ($q_{t,net}= q_t$ − returns), not on gross abstraction q_t.

67. Compilation approaches for MAR volumes and return flows include: (a) direct metering at injection wells or return-flow gauging points; (b) residual estimation from the stock identity; (c) sector-specific return flow fractions from national water balance models or literature benchmarks, noting that agricultural return fractions range widely (typically 10–40%) depending on soil type, irrigation method, crop type, and depth to water table; and (d) isotope or tracer studies to distinguish recharged-water contributions to the stock in areas with mixed recharge sources. Where direct metering is unavailable, Tier 2 estimates should be accompanied by a quality indicator in the metadata.

3.3 From Physical to Monetary: The Monetary Supply-Use Table

3.3.1 What the standard monetary accounts capture

68. 'Standard monetary accounts' in this Guidance Note means national accounts as typically compiled and published, not the full SNA production boundary: own-account and non-market water use fall within that boundary conceptually but are rarely observed or valued in practice. ISIC division 36 covers water collection, treatment, and supply by utilities, while CPC 1800 covers the distributed water supply product (United Nations Department of Economic and Social Affairs, 2008, 2015). In countries with metered, priced public supply systems, these transactions appear as intermediate consumption across industries and as household final consumption; consequently, the exchange value of the water product is fully and directly captured within standard monetary accounts.

69. Market-recorded values reflect the transaction price. For regulated utilities, that price covers operating costs, capital costs, and a regulated rate of return but typically not resource rent, which is the additional return to the water stock above the full cost of supply.[5] A regulated water utility in a water-scarce basin that charges average cost recovery prices records no resource rent. This is the administered-pricing zero-rent case addressed by Recommendation 5 (§3.4): the recorded zero does not indicate the resource is unscarce, and compilers should move directly to a Tier 2 method rather than report the observed zero

[5] In practice, many regulated utilities — including the majority of EU water service providers — do not recover full costs; the gap between regulated tariffs and cost recovery is itself evidence that resource rent is absent from observed prices.

at face value. Absent that correction, the accounts show water as a produced input, not a depletable natural resource.

70. The Central Framework monetary asset account and the SEEA Ecosystem Accounts record different economic phenomena relating to the same physical water and are not additive (§2.2). The CF records the resource rent of the extracted stock, the return to the resource owner above the full cost of extraction. The SEEA EA records the provisioning service value of water supply, the contribution of the ecosystem to economic activity, using the same exchange-value concept as the SNA and CF (SEEA EA §8.8), applying the same preference-ordered valuation techniques, including resource rent, that this note uses for the CF account (SEEA EA §§9.22–9.25, 9.36).

3.3.2 The own-account abstraction gap

71. Excluding hydropower, agriculture globally abstracts roughly 70% of freshwater withdrawals (Ingrao et al., 2023; Food and Agriculture Organization [FAO] AQUASTAT, 2022). In Pakistan, irrigation accounts for approximately 93% of total freshwater use, nearly all from own-account abstraction by farmers (Government of Pakistan, 2018). Farmers abstracting from often-unmetered canals or unregistered wells generate no water transaction in the accounts (though in many jurisdictions wells and diversions are metered and remote sensing increasingly supports basin-scale abstraction estimation). Their water use is economically significant and physically documented in the PSUT, but invisible in the monetary supply-use tables as typically compiled, a gap in observation and valuation practice, not in the SNA production boundary.

72. The gap has direct consequences for natural capital accounting. If own-account abstraction is excluded, the depletion charge in §3.6 undercounts water depletion for countries where agriculture dominates. The PSUT provides the physical volumes needed to close this gap. The valuation methods in §3.4 provide the prices. Together they allow the compiler to construct a complete monetary supply-use table that includes non-market water flows alongside market-transacted water.

73. The treatment of own-account abstraction differs importantly between surface water and groundwater. Groundwater is a depletable stock that accumulates across periods; its shadow price rises as the stock is drawn down, and own-account depletion reduces future productive capacity in a straightforward accounting sense. River water is fundamentally non-storable: water not abstracted in the current period flows downstream and leaves the accounting territory, so the opportunity cost of non-abstraction is fundamentally different. Lakes and artificial reservoirs are renewable but depletable. Snow, ice and glaciers are treated as non-renewable in this Guidance Note (§3.6.1): global glacier mass balance has been negative and accelerating since at least 2000 (Hugonnet et al., 2021), so unlike lakes and reservoirs, glacier volume lost is not expected to be replenished within a compilation-relevant time horizon.

74. Fenichel et al. (2016) show how the production-function approach handles these distinctions within a common capital-theoretic framework; compilers dealing with predominantly river-fed systems should consult that approach before applying groundwater-derived discount-rate formulas directly. Compilers often default to the standard perpetuity or finite-horizon NPV formula developed for groundwater stocks, overlooking that a flowing river's capacity to sustain rent is better represented as sustained yield (§3.1.1) than as a fixed reserve. The treatment is more complex for surface water subject to use-it-or-lose-it appropriation rights, where abstraction timing constraints affect the rent calculation.

3.3.3 Water quality and the usable stock

75. The physical asset account as described in §3.2.3 treats the water stock as homogeneous: one cubic metre counts the same regardless of salinity, dissolved solids, temperature, or pollutant load. In practice, quality determines whether water is usable for a given purpose. Brackish groundwater and pristine alpine stream water carry fundamentally different resource rent values but appear as equal volumes in the standard PSUT and asset accounts.

76. Quality changes arising from natural processes that affect the usable stock (e.g., drought-driven concentration of dissolved solids increasing an aquifer's salinity, flood-borne sediment deposition reducing stream water clarity, natural mineral leaching making previously usable groundwater brackish) should be recorded in the other changes in volume row of the physical asset account as downward stock adjustments, labelled to indicate a quality reclassification (e.g., "reclassification due to change in quality") rather than a volumetric loss. Because the measurement unit remains m^3, the reclassification does not reduce the physical volume held; it re-labels a portion of that volume as no longer usable for the purpose tracked in the account.

77. Where quality tracking is material, compilers may extend Table 3.1 with quality-differentiated columns (e.g., by salinity or treatment-requirement class) to show these reclassifications explicitly; developing standard guidance for that extension is identified as a 2028 methodological priority (§5.4, priority 3). Conversely, technological advances enabling purification of previously marginal water (desalination, treatment) can expand the effective usable stock and should be recorded as upward OCV adjustments. Desalination of open-ocean seawater draws from a source outside the physical asset account and does not by itself constitute an upward OCV adjustment; the treatment described here applies only to purification or treatment of water already within the AN.34 boundary, such as brackish groundwater or degraded surface water. These physical adjustments flow directly into the monetary asset account: a quality-driven reduction in S lowers the balance sheet value.

78. Where compilers have not yet implemented quality grading, the unit price $\bar{p}$ is held constant as a simplifying assumption and the effect is captured entirely through the volume adjustment. Where quality grading is available, degradation is more accurately captured as a downward reclassification from a higher-price to a lower-price quality grade, changing both S and the applicable $\bar{p}$, and that approach is preferred where data support it. This treatment applies to quality changes from natural or exceptional sources. Quality changes arising from continuous anthropogenic economic activity are governed by a different accounting logic and are addressed below.

79. Where quality data are sufficient to support adjustment of the usable stock volume S or the resource rent F_t, those adjustments should be made and the method documented. This is consistent with the river-basin-level compilation approach recommended in §3.2.2.

80. Current SEEA CF and SEEA-Water guidance does not differentiate water resources by quality, and no standard quality-classification classes exist for national accounts purposes. Developing such guidance is a research priority for the 2028 update (see §5.4).

81. A critical distinction governs the accounting treatment of water quality change: the source of degradation. Quality changes arising from natural processes (described above) are appropriately recorded as OCV entries in the physical and monetary asset accounts, because they are not the output of an economic production process. Quality changes arising

from continuous economic activities (agricultural runoff, industrial discharge, urban stormwater) are a different matter in one respect: they are foreseeable, recurring consequences of production, not exceptional natural events. Current SNA and SEEA CF practice nonetheless records all quality degradation, natural or anthropogenic, as an OCV entry (SNA 2025 §13.32), with any resulting decline in value attributed to the resource owner rather than to the producing sector responsible for it.

82. This note proposes that the updated SEEA CF consider a departure from that convention for continuous anthropogenic degradation: recording a degradation cost traceable to the producing sector, reported parallel to the depletion charge D rather than merged into it, would keep the cost of a foreseeable, recurring externality visible at its source rather than folding it into a volume-change entry against the owner’s balance sheet. This is a proposal for discussion, not a description of current practice. TC Question 4 asks the TC to indicate a preference among three approaches, of which this note's own preference is the parallel structure described here (Approach B, below). Compilers should note that OCV is the current convention for all quality degradation regardless of source, and that departing from it for anthropogenic degradation, as this note proposes, is a matter for global consultation rather than settled guidance.

> ***TC Question 4:*** *Should the updated SEEA CF introduce a monetary degradation cost for water quality loss, separate from depletion and from OCV stock adjustments? Three approaches are under consideration: (A) quality changes are fully captured through OCV stock adjustments with no separate degradation line; (B) a degradation cost is calculated and reported as a supplementary item alongside but outside NDP, parallel to the depletion charge rather than merged into it (this note's preferred structure, §3.3.3); or (C) quality-adjusted depletion replaces the standard quantity-based depletion charge where quality data are available. Countries should report their current practice and whether data infrastructure exists to support option (B) or (C).*
>
> Note: The three approaches in this question apply to different pollution sources. For anthropogenic quality degradation from ongoing economic activities, Approach (A) OCV adjustment only (including adjusting p̄ itself via quality grading, which is structurally the same mechanism) is not recommended as the sole treatment, because it misclassifies an economic cost as a natural volume change and breaks the link to the responsible sector; that conclusion holds regardless of the still-open choice between Approaches (B) and (C), and does not itself resolve TC Question 4. Countries selecting Approach (A) for anthropogenic degradation should explain the data or conceptual constraints that prevent applying Approach (B) or (C).

3.4 Valuation Methods: Estimating the Resource Price

83. The goal of this section is an estimate of resource rent: the net return to the water stock above the full cost of extraction, expressed as a price per unit volume. This price is required to value water flows in the monetary supply-use table and, through the relationship between current rent and expected future rents, to derive the asset account stock price p̄ (§3.5). For most water resources, observed prices do not reflect scarcity; they are zero, regulated below cost recovery, or bundled with delivery charges that cannot be separated from the resource component. In those cases, which represent the norm rather than the exception, the compiler must estimate the resource rent indirectly. This section describes six estimation options organized in a two-tier hierarchy, with a conditional sub-tier within Tier 2, and provides guidance on choosing among them.

84. **The tier system organises methods by their proximity to an observed exchange price and by data requirements.** Tier 1 methods use directly observed market prices or rents where competitive transactions exist and prices genuinely reflect scarcity. Tier 2 methods estimate an exchange-value-compatible price indirectly (through cost substitution, productivity analysis, market inference, benefit transfer, or travel cost) for the majority of water resources where Tier 1 conditions do not hold. A sub-category, Tier 2 Conditional, applies to methods that require specific data conditions (e.g. competitive water-rights markets, or water being the binding constraint on production) before they should be used in monetary accounts. Stated preference methods, including contingent valuation, should not be used to estimate resource rent but they may be used to estimate values that are relevant for some purposes and hence they may appear in supplementary tables (see §5.1). Compilers should apply the highest-tier method for which sufficient data exist, document the choice, and note any conditional requirements satisfied in the metadata.

3.4.1 What the compiler is estimating

85. The theoretically correct price is $p^* = \partial V/\partial S$, the marginal value of an additional unit in the stock, which depends on the entire future extraction path and the discount rate. In practice, compilers observe changes in water and use these to impute local prices. The Hicks-Harberger approximation (Harberger, 1971) between water stocks a and b is $\Delta V = ½ (p_a + p_b) \times (s_b - s_a)$. Note: this approximation applies to changes in stock value between two points; applying it to value the entire stock from zero requires knowing the price at zero stock (p_0), which is undefined for scarce resources, reinforcing why §3.5 estimates V first, at both the opening and closing stock, and derives $\bar{p}$ from the two (the V-first approach, eq. D.4), rather than pricing the stock directly. This approach uses the average marginal value per unit, to measure the value in the change in the stock. This approach is valid when changes in the stock are small relative to total stock ($\Delta S/S \ll 1$) and substitution effects are small or symmetric (Diewert, 1992). When these conditions do not hold, the Fisher Ideal and Tornqvist indices provide improved second order approximations. §3.5.4 describes the conditions under which this approximation holds and where it breaks down.

3.4.2 Option A (Tier 1): Market prices

86. Where competitive water markets exist and transactions are observed at prices that reflect scarcity conditional on prevailing institutions, those prices can serve directly as the resource rent estimate. However, they often must be corrected because the quantity of water and the delivery process are often charged jointly. The conditions are demanding: markets must be competitive (no regulatory price caps below resource rent), transactions must be at arm's length, and price data must be spatially matched to the water resource being valued. Compilers should verify that all three conditions above are met and, in particular, that observed prices incorporate resource rent rather than reflecting regulated or administratively capped tariffs.

87. The Murray-Darling Basin in Australia has a water trading market with publicly reported transaction prices (Walsh, 2021), making it one of the few cases where Option A is straightforwardly applicable (Grafton et al., 2012). Chile's water rights trading system provides another example, though price data coverage varies by region (Araos and Roco, 2025; Bauer, 2008). These recurring examples are not a coincidence of data availability: prior appropriation and similar quantified, transferable-rights regimes are what produce a market to observe in the first place, so a jurisdiction with riparian, communal, or customary tenure is structurally unlikely to generate Tier 1 evidence regardless of compilation effort, and should expect to work from Tier 2 instead (§2.1). Where market prices are used,

compilers should verify that observed prices incorporate resource rent and are not regulated or administratively capped.

88. Reas et al. (forthcoming) apply a PRISMA 2020 meta-regression to exchange-value-compatible water valuation studies, explicitly excluding stated preference methods on the same grounds as this Guidance Note. Their dataset of 61 observations across 18 countries (2000–2025) provides an empirical basis for benefit transfer and an observed range for F_t. Among 18 observations conducted within a SEEA EA framework, unit values cluster between Int$0.02 and Int$3.51 per cubic metre for drinking water supply. Critically, not one of the 61 observations estimates a balance sheet asset value V, all are annual flow value estimates F_t. This gap directly motivates the $F_t \rightarrow V$ conversion in Annex A and confirms that the depletion chain requires a dedicated conversion step even where unit prices are well-established.

3.4.3 Option B (Tier 2): Cost-based price substitution (also: Replacement cost)

89. Where markets are absent or prices are regulated below resource rent, compilers can substitute an estimate of the cost of the next-best alternative water source. This approach is equivalent to the replacement cost method as described in the SEEA Ecosystem Accounting preference hierarchy (UNSD et al., 2024).

90. (Note: replacement cost estimates are only valid as shadow prices when the replacement would genuinely be pursued, i.e., when the alternative supply represents the actual next-best option being implemented; hypothetical or unrealistic replacements overstate the true water value. Imputed, modeled, or hypothetical engineering costs are strictly prohibited; compilers must rely solely on ex-post, audited financial records of actual capital and operational expenditures. The value of the resource calculation should deduct depreciation produced capital from expenditures.)

91. If expanding water supply would require shifting to desalination or inter-basin transfer at a known unit cost, that cost establishes a reference point for the scarcity value. Cost substitution captures avoidance cost rather than the full rent to the stock, but it is more defensible than zero for water stocks where physical scarcity is established.

92. The Netherlands uses a form of cost-based reference pricing for its water resource accounts, drawing on the cost of managing water quality to a defined standard (Edens and Graveland, 2014). López-Morales and Mesa-Jurado (2017) apply replacement cost to the aquifer system in central Mexico, estimating the value of services that remain invisible in market prices ("hidden water ecosystem services"), a useful illustration of the method in a data-sparse developing-country context. The method is appropriate when water prices are zero or regulated below cost recovery, physical evidence of scarcity exists, and cost data for credible alternatives are available.

3.4.4 Option C (Tier 2 Conditional): Residual value and related productivity-based approaches

93. The **residual value** approach is one way to estimate resource rent empirically: after deducting all produced factor payments (labour, capital, and intermediate inputs) from the gross output value of the activity using water, the remainder is attributed to the natural resource input. This approach requires that water be the binding constraint on output. If expansion is limited by capital, management, or market access rather than water availability, the residual will overstate the rent to water. The Guadalquivir River Basin in Spain provides a documented application of residual value to agricultural water in a water-scarce river basin

(Berbel et al., 2011). The SEEA-Water framework provides complete, worked data structures and template matrices for compiling physical and monetary supply and use accounts within its core technical chapters and standard appendices (UNSD et al., 2012).

94. **Production function variant.** An alternative to the subtraction residual is to estimate the marginal product of water directly from a production function. Where output Y is modelled as a function of capital K, labour L, water W, and other inputs, the term $\partial Y/\partial W$ gives the implicit price of water as a productive input (This is the approach developed in Fenichel and Abbott (2014) and applied to groundwater in Fenichel et al. (2016); compilers must adjust for capital gains and depreciation; the open-source capn tool (https://github.com/ysd2004/capn), whose methodology derives from Fenichel and Abbott (2014), implements the production approach adjusted for capital gains; see also Manning and Barbier (2025) for related methods.). This is exchange-value compatible. It estimates what a competitive market would pay for the marginal unit of water, and is particularly useful for own-account abstractors where the full cost data required for the subtraction approach are unavailable. Under competitive conditions and constant returns to scale, the production function estimate and the subtraction residual converge; material divergence signals that water is not the sole unpriced factor, that factor markets are imperfect, or simply that data uncertainty or differing calculation/methodological choices between the two estimates account for the gap, compilers should rule out the latter before concluding the divergence is economically meaningful. Compilers using this approach should document the functional form, data sources, and estimation method, and check the resulting estimate against Option A or Option B benchmarks where available.

95. **Choosing between Option B and Option C.** The two Tier 2 methods can produce substantially different estimates for the same water stock: replacement cost (Option B) estimates the avoidance cost of the next-best alternative supply, while residual value (Option C) estimates the productivity contribution of water in its current use. Country evidence suggests the two can diverge substantially for the same resource, since the methods measure conceptually different things, an avoidance cost versus a productivity contribution, rather than converging on a single water price (Young and Loomis, 2014). Option C (residual value or production function) is preferred when water is demonstrably the binding constraint on output and cost data for alternative sources are unavailable or unreliable. Option B is preferred when physical scarcity is established but the water–output relationship is difficult to isolate econometrically. Where both can be computed, compilers should report both estimates and document the difference in metadata, as the divergence itself carries information about the degree of market failure in water pricing.

96. **Multi-sector abstraction from the same source.** Where multiple sectors with substantially different marginal value products draw from the same source in the same river basin, the resource rent estimate from Option C reflects only the sector from which it is derived. A residual value or production function estimate based on agricultural data should not be applied without adjustment as the resource price for the same source supplying industrial or municipal users whose marginal value products may differ substantially.

97. In this case compilers should: (a) identify the marginal user (i.e., the sector whose demand would be curtailed by a small reduction in supply) and base the resource rent estimate on that sector's data; (b) where multiple sectors compete for the same source and the marginal user cannot be clearly identified, estimate sector-specific residual values and compute a quantity-weighted average as the single resource rent; and (c) document in metadata which sector(s) the estimate is derived from and note any sectors for which higher marginal value products are suspected but unquantified.

98. Where substantial divergence in sectoral marginal value products is suspected, a supplementary table comparing sector-specific residual values alongside the main accounts is recommended, as that divergence is evidence of misallocation or regulatory constraint relevant to water governance.

3.4.5 Option D (Tier 2 Conditional): Hedonic pricing

99. Hedonic pricing infers the implicit price of water access from observed differences in land or property values where water rights are bundled with land. Where comparable sales data are available in a competitive real-estate or water-rights market, hedonic regression isolates the water price premium from other land attributes. The resulting estimate reflects exchange value (what the market implicitly charges for the marginal unit of water access) and is consistent with SEEA CF requirements. Hedonic methods are exchange-value-compatible for the same reason that production function approaches (Option C) are: both recover a market-consistent implicit price rather than a welfare measure. The difference is the data source: hedonic pricing identifies water value from asset market transactions, while production function estimation identifies it from output and input variation across producers.

100. Option D is classified as Tier 2 Conditional rather than Tier 1 because the method requires a competitive real-estate or water rights market with sufficient transaction volume to identify the water coefficient separately from other land attributes. Where property markets are thin, regulated, or do not separately record water rights, the hedonic coefficient cannot be reliably estimated. Where data conditions are met and the resulting price can be verified against Option A or B benchmarks, Option D estimates may be used in the monetary accounts. Compilers should document the functional form, data sources, and any adjustments made to achieve spatial matching between the hedonic price estimate and the water resource being valued.

3.4.6 Option E (Tier 2): Benefit transfer

101. Where primary data collection is infeasible, compilers may apply benefit transfer: adapting an exchange-value-compatible unit price estimate from a documented Tier 1 or Tier 2 study to the target water resource. The source study must satisfy the same exchange-value conditions as Option A or Option B/C directly (estimates from stated preference methods are not eligible source values for benefit transfer into monetary accounts). Empirical validity requires that transfer adjustments control for heterogeneities between the source and target contexts, including water typology, scarcity gradients, institutional configurations, and income distributions.

102. Consequently, a regression-based transfer function approach is preferred over simple point transfers, as it dynamically scales unit values based on target site parameters (see Johnston and Bauer, 2019); because such a function typically pools multiple primary studies rather than drawing on a single source, compilers should document every primary study feeding the function, not only cite the function itself. Even a well-specified transfer function is demanding to build and validate, and successful applications remain the exception rather than the rule, particularly where source and target sites diverge on several dimensions at once, water typology, scarcity, institutions, and income, simultaneously (Bateman et al., 2011).

103. Benefit transfer produces lower-confidence estimates than primary estimation and should be clearly labelled in metadata as a transferred value with the source study cited. It is

appropriate as an interim measure while primary compilation capacity is developed, not as a permanent substitute for primary estimation.

104. This note does not yet specify a sampling and scaling strategy for aggregating benefit-transfer estimates to national-level water resource values. That question, how to select a representative sample of water bodies and scale transferred unit values to the national account, and how to aggregate nationally when different river basins have used different valuation options (A through F), remains an open methodological gap for the 2028 SEEA CF update.

3.4.7 Option F (Tier 2 Conditional): Travel cost

105. Option F does not value water resources for non-consumptive or amenity uses generally. It prices a productive use of the resource that meets the same accounting conditions as the in-stream uses recognised in §3.8.2 (hydroelectric generation, thermal cooling, canal operation): a legally defined use right exists, and the water generates measurable economic benefit as a productive input, but no market or cost-based price is observable. For Option F specifically, that productive use is one where the benefit is captured through travel or access expenditure, such as commercial fisheries, guided recreation, or water-dependent tourism (§3.4.7), not hydropower, cooling, or canal operation themselves, which have no traveling users to observe. Travel cost methods infer the implicit price of access to a water resource from observed variation in travel expenditure across users. When used correctly to recover a **price**, i.e. the marginal cost of access per unit of the resource, derived directly from observed expenditure data, the method is exchange-value compatible and eligible for use in monetary accounts. It does not require estimating the elasticity of the demand curve; it uses the observed travel cost as a revealed exchange price in the same way that Option A uses observed market transaction prices.

106. The method is classified Tier 2 Conditional rather than Tier 1 because its application to water resource valuation requires care on two fronts. First, as with the in-stream uses recognised in §3.8.2, the resource must be connected to a productive use under a legally defined use right that generates measurable economic benefit as a productive input, evidenced by SNA-recorded output or by observable, measurable access expenditure (commercial fisheries under a fishing licence, guided recreation with a concession agreement, water-dependent tourism operations with defined access rights). General recreational access with no defined use right, or existence and amenity values with no link to production, are outside AN.34 scope and outside Option F. Second, and critically, the price must be derived from observed travel cost data, not from integrating the demand function. Estimates that hinge on an elasticity assumption produce consumer surplus (a welfare measure) rather than an exchange price, and are outside the monetary account hierarchy for the same reasons as Option E.

107. Where these conditions are met and the resulting unit access price can be verified against an Option A or B benchmark, Option F estimates may be entered in the monetary accounts. Where the application requires an elasticity estimate to derive the price, the result should be treated as outside scope, not as Tier 3.

3.4.8 Stated preference methods

108. Contingent valuation, choice experiments, and related stated preference methods elicit hypothetical willingness-to-pay or willingness-to-accept from survey respondents. These

methods could measure total economic value, including consumer surplus, and are designed to evaluate policy changes rather than to recover exchange prices. They are not eligible for use in the monetary supply-use table or the water resource asset account for three reasons. First, in level terms they capture values including consumer surplus which is excluded from the target exchange value concept. Second, most stated preference studies are designed to value changes from a baseline under constant policy, not changes in physical quantity under constant prices, the quantity that the monetary accounts require. Third, the boundary between the resource rent component and the total welfare value is not separately identified in standard stated preference outputs.

109. These methods may have a role in complementary accounts that sit alongside but outside the SEEA CF monetary boundary, where total economic value estimates are relevant for policy. Whether stated preference based welfare estimates can be normalized to recover an exchange-value-compatible price component is an open research question; current guidance does not support their use in monetary accounts pending that resolution.

3.4.9 Choosing among methods

110. The tier hierarchy and per-option conditions were introduced in §3.4.1 through §3.4.8. What follows applies those conditions as a single decision procedure, plus two rules not stated earlier: how to handle cases where more than one method is available, and the boundary between eligible and ineligible estimates.

Table 3.2: Method selection at a glance (see §3.4.1–§3.4.8 for full conditions and worked rationale)

Tier	Option	Use when	Verify against
1	A: Market prices	Competitive market, arm's-length transactions, prices spatially matched to the resource. Also covers the resource rent / net price method where observed prices genuinely reflect scarcity.	No other method required
2	B: Replacement cost	Physical scarcity established; cost data for a credible alternative supply (e.g. desalination, inter-basin transfer) that would genuinely be implemented are available.	Option A, if available *Only valid if the alternative would actually be pursued; compare against Option C where both are computable (§3.4.4).*
2 Cond.	C: Residual value / production function	Water is demonstrably the binding constraint on output. Production-function variant preferred for own-account abstractors; subtraction residual preferred when full cost data are available.	Option A or B *Preferred over B where credible alternative-supply cost data are unavailable or unreliable.*
2 Cond.	D: Hedonic pricing	Competitive property or water-rights market with sufficient transaction volume; water rights separately identifiable in transaction records.	Option A or B *Unreliable where property markets are thin or regulated.*
2	E: Benefit transfer	Primary estimation infeasible; source study is a documented Tier 1 or Tier 2 estimate meeting exchange-value conditions; a transfer function (not a simple point transfer) adjusts for site characteristics.	Source study cited in metadata *Interim measure only, while primary compilation capacity is developed — not a permanent substitute for the other options.*
2 Cond.	F: Travel cost	Recovers an exchange price (marginal access cost from observed expenditure), not a surplus requiring an elasticity assumption; applied to a productive use with SNA-recorded output.	Option A or B *Must recover a price from observed expenditure directly, not by integrating a demand curve; elasticity-based estimates are out of scope.*
Ineligible	Stated preference; surplus-based travel cost	Measures total economic value including consumer surplus, not exchange value, regardless of data quality or study design.	Not applicable

Tier 1: use if available

111. Option A (market prices) is preferred where applicable. Before accepting observed prices as Tier 1 estimates, verify three conditions: markets are competitive with no binding price caps below resource rent; transactions are at arm's length; and prices are spatially matched to the resource being valued. Where these conditions are met, no other method is required. Where they are met only for part of the resource base, apply Option A to those sub-basins and a Tier 2 method elsewhere, reporting the split in metadata.

112. The standard resource rent / net price method (extraction revenue minus extraction costs) is also Tier 1 where observed prices genuinely reflect scarcity. For most water resources, regulated or zero prices mean this method yields zero or negative rent; in that case move directly to Tier 2. Recommendation 5 addresses this case.

Tier 2: use when Tier 1 is unavailable

113. Tier 1 conditions fail for the great majority of water resources. Options B, C, D, E, and F are all exchange-value-compatible but capture different aspects of water value and differ in data requirements. Options C, D, and F carry additional conditions that must be satisfied before they may be used in monetary accounts.

114. Option B (replacement cost) measures avoidance cost (the price required to induce substitution to the next-best alternative supply). Use when physical scarcity is established and cost data for a credible alternative supply (desalination, inter-basin transfer) are available. Option B is only valid as a shadow price if the alternative would genuinely be implemented; hypothetical or uneconomic alternatives overstate resource rent.

115. Option C (residual value / production function), Tier 2 Conditional measures productivity contribution: the marginal output attributable to water in its current use. Use when water is demonstrably the binding constraint on production and cost data for alternatives are unavailable or unreliable. The production function variant is preferred for own-account abstractors; the subtraction residual is preferred when full cost data are available.

116. Option D (hedonic pricing): Tier 2 Conditional infers access value from property or water-rights market transactions. Use only where a competitive real-estate or water-rights market with sufficient transaction volume exists and water rights are separately identifiable in transaction records. Verify results against an Option A or B benchmark.

117. Option E (benefit transfer): Applies a unit value from a documented Tier 1 or Tier 2 primary study to the target resource. Use only when primary estimation is infeasible, the source study satisfies exchange-value conditions, and a transfer function is used to adjust for site characteristics. Welfare-value estimates from stated preference studies are not eligible source values for benefit transfer into monetary accounts. Label transferred values in metadata with the source study cited. Benefit transfer is appropriate as an interim measure while primary compilation capacity is developed, not as a permanent substitute.

118. Option F (travel cost): Tier 2 Conditional may be used in monetary accounts when it recovers an exchange-value-compatible **price**: the marginal cost of access per unit of the resource derived from observed travel expenditure, without requiring an elasticity estimate. Where the method is applied to a productive use with SNA-recorded output and yields a unit access price verifiable against an Option A or B benchmark, it is eligible for the monetary supply-use table and asset account on the same basis as Options C and D. Where the

estimate instead hinges on an elasticity assumption, producing a consumer surplus figure rather than a price, the result is a welfare measure and falls outside the monetary account hierarchy; see below.

119. Where both Option B and Option C can be estimated, report both. Divergence between replacement cost and residual value reflects the degree of market failure in water pricing and carries diagnostic information about the state of the resource market.

120. Two types of estimates are ineligible for any tier of the monetary accounts regardless of data quality or study design. *Stated preference methods* (contingent valuation, choice experiments, and related approaches) can measure total economic value including consumer surplus. Consumer surplus has no counterpart in SNA-recorded transactions. See §3.4.8 for the detailed rationale. *Surplus-based travel cost estimates* that hinge on an elasticity assumption produce consumer surplus rather than an exchange price and are similarly outside scope. Note that this is a property of how the travel cost model is used, not of the method itself: travel cost applied correctly to recover a price (Option F) is eligible; travel cost applied to integrate a demand curve and report surplus is not. Stated preference and surplus-based travel cost estimates may be relevant for welfare analysis or environmental impact assessment conducted outside the SEEA CF framework.

121. The method selected should remain consistent across accounting periods. Switching methods creates apparent changes in asset value that may reflect methodological choice rather than real economic change. If circumstances require a change, for instance, a water market is established in a basin that previously used residual value, construct a linked series showing both methods for the overlap period so users can assess the discontinuity.

3.5 Stock Valuation

3.5.1 From resource rent to asset value

122. The primary estimation target in balance sheet valuation is $p^* = \partial V/\partial S$: the shadow price of a unit of water stock, equal to the marginal increase in total asset value from a marginal increase in stock (Fenichel, Obst and Wentland, 2024). This note follows the capital-theoretic resource valuation literature (see also Fenichel and Hashida, 2019) in calling p^* a shadow price. The term does not appear in the SNA 2025 or the SEEA CF 2012; compilers should read it as vocabulary borrowed from that literature for the marginal asset price $\partial V/\partial S$, not as an existing SNA or SEEA CF category. Total asset value V is estimated first, as the net present value (NPV) of the future stream of resource rents; the unit price used in the accounts, $\bar{p}$, is then derived as the average of V/S at the opening and closing stock (§3.5.1, eq. D.4), simplifying to V/S_0 alone within the small-$\Delta S/S$ regime this note treats as the baseline case (§3.5.4), not the other way around. Where $\Delta S/S$ is not small, §3.5.4 sets out the Fisher Ideal / Törnqvist alternative, which does not reduce to a single derived $\bar{p}$. This ordering matters: pricing the stock directly, by integrating a unit price from its current level down to zero, would require knowing the price at zero stock (p_0), which is undefined for a scarce resource (§3.4.1). Capitalizing the rent flow avoids that problem entirely, since it never prices the stock directly. Under this approach, total asset value is first approximated as:

$$V = \sum_{t=1}^{T} \frac{F_t}{(1+r)^t}$$

123. where $F_t = R_t \times q_t$ is the total resource rent flow in period t (the per-unit resource rent R_t multiplied by the volume extracted q_t), r is the discount rate, and T is the asset life. Most of the variation in V across country estimates is driven by: the institutions governing water allocation and human behavior; complementary capital; the boundary of water types included in the stock account (§3.1); the method used to estimate the resource rent (§3.4), the discount rate (§3.5.2), the approach used to estimate p* from observed rents (§3.5.3), and whether to estimate V at the river basin level or aggregate first to national totals (§3.2.2, §3.5.3).

3.5.2 The discount rate

124. The discount rate reflects the (risk free) opportunity cost of capital in the economy. SEEA CF §5.4.5, paras. 5.145–5.150 and Annex A5.2 discuss the choice between market-based and social discount rates in detail; SEEA EA §§10.75–10.79 covers the same choice for ecosystem service valuation. A higher rate reduces asset value by compressing the weight given to distant future rents; a lower rate magnifies the value of long-lived assets. For a constant resource rent flow of 100 per year in perpetuity: at 3%, V = 3,333; at 5%, V = 2,000; at 10%, V = 1,000. Annex E, Examples 1–4 illustrate this sensitivity across finite and perpetuity horizons. (This follows from the perpetuity formula V = R/r; compilers should therefore test a range of plausible rates rather than anchoring on a single value.)

125. Lange (2004) used a 4% discount rate for natural capital accounts in developing countries, arguing it was consistent with long-run social rates of time preference. Current practice in many OECD countries uses 2–5%. Countries should use a rate consistent with their broader national accounts practice and document their choice explicitly. One approach to setting the discount rate is to use the cost of long-term government debt adjusted for expected inflation, as applied in U.S. federal natural capital accounts (Office of Science and Technology Policy et al., 2023). Sensitivity analysis across a range of plausible rates should be reported alongside any central estimate.

126. Country practice on discount rates is the subject of GC Question (f) (§5.3). Compilers are asked to report the rate used, its justification, and whether sensitivity analysis was published alongside the central estimate.

3.5.3 p* and the Harberger approximation

127. Under competitive equilibrium, the shadow price p* satisfies the Hotelling condition, which states that the total return on holding a unit of stock must equal its opportunity cost:

$$r \cdot p^* = W_s + \dot{p}^* + g'(S) \cdot p^*$$

128. where r is the discount rate; $W_s = \partial(R_t\, q_t)/\partial S$ is the marginal capital service flow (resource rent dividend); $\dot{p}^* = \partial p^*/\partial t$ is the rate of price appreciation (capital gain on the asset); and $g'(S) \cdot p^*$ is the stock-growth effect, the marginal value of the induced recharge generated by holding an additional unit of stock. The left side $r \cdot p^*$ is the opportunity cost of the unit. The production approach (Annex A) estimates p* by solving this condition from observed rent and stock data, rather than relying on the rent-equals-marginal-value assumption, $R_t = p^*$, that this note's operational method uses to make V computable from observed data (§3.5.1).

129. The theoretically correct stock price is

$$p^* = \frac{\partial V}{\partial S}$$

130. the marginal value of a unit of stock. In practice, V is not estimated by integrating a unit price over the stock down to zero, since that would require the price at zero stock, p_0, which is undefined for a scarce resource (§3.4.1). V is instead estimated from the net present value of the resource rent flow (§3.5.1, eq. D.2), and the operational unit price used throughout this note,

$$\bar{p} = \frac{V}{S_0} \; (simplified\ form\ of\ eq. D.4, valid\ where\ \Delta S/S\ is\ small, §3.5.4)$$

is derived from that total, once V is known, not estimated independently from a locally observed pair of prices. $\bar{p}$ is the single unit price used consistently throughout the depletion charge, revaluation, and OCV formulas below; it is a reporting ratio, not an input for computing V.

131. For large, slowly depleting aquifers, the approximation is adequate. For small or heavily stressed water bodies where ΔS/S is not negligible, the error associated with the $\bar{p}$ increases. That error does not show up inside the reported OCV entry itself; it is quantified separately as D_{gap}, the exact gap between the operational depletion charge (computed with $\bar{p}$) and the true depletion charge that would result from using p* instead (§3.6.3).

132. The spatial scale of the price estimate matters. A national average $\bar{p}$ aggregates across river basins with very different scarcity levels. Water in an over-allocated basin and water in a well-recharged highland system carry different rent values; using a national average assigns both the same value, erasing the spatial signal that makes the accounts useful for allocation decisions. Addicott and Fenichel (2019) demonstrate this problem formally: national $\bar{p}$ is spatially meaningless for policy. River-basin-level $\bar{p}$ estimates are strongly preferred. This is a result of the well-known modifiable areal units problem (Figure 3.2).

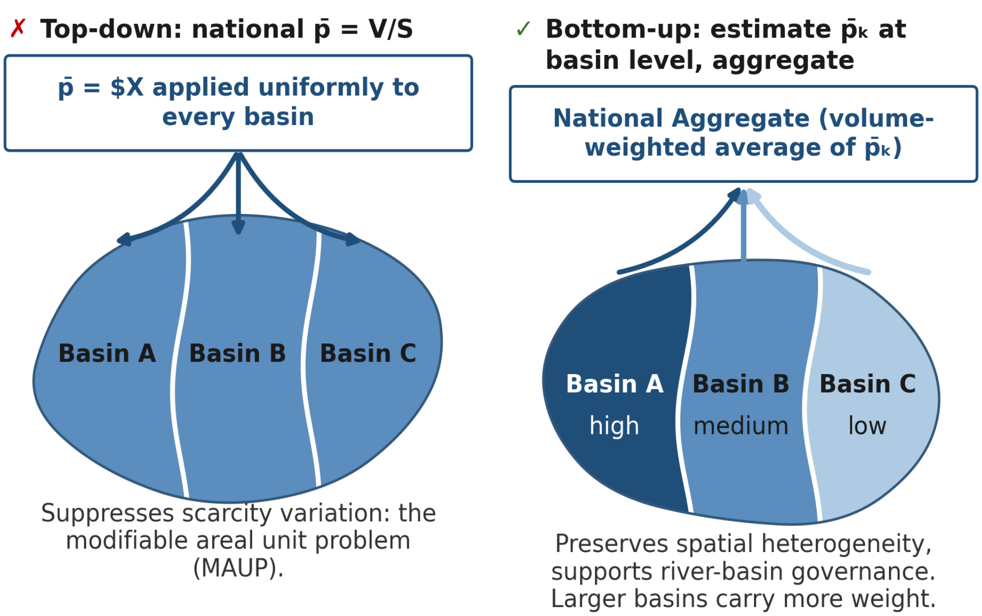

Figure 3.2. Spatial aggregation and the modifiable areal unit problem.

A national average price $\bar{p} = V_{national} / S_{national}$ (top-down) suppresses river-basin-level scarcity variation and produces accounts that cannot support water governance decisions. The recommended approach (bottom-up) estimates V_k, and the average price $\bar{p}_k$ it implies, at the river basin level and aggregates upward, preserving spatial heterogeneity. Recommendation 6 requires river-basin-level compilation; national aggregates are summary statistics only. See §3.2.2.

3.5.4 Index numbers and time consistency

133. When the stock changes substantially between periods, unit price and quantity both change, and the measurement of changes in asset value depends on whether price or quantity changes are weighted by opening- or closing-period values. For most water accounts, where stock changes are small relative to total stock (compilers should apply judgment based on aquifer characteristics), arithmetic averaging of opening- and closing-period prices is adequate (Diewert, 1992). In practice, price series may not fully reflect near-term stock changes, particularly where prices are regulated, and compilers should document any known lag between physical depletion and price response in the metadata.

134. Where stocks change rapidly (over-allocated aquifers, or surface systems recovering from severe drought), Fisher Ideal or Törnqvist index approaches are appropriate (Diewert, 1992). These preserve the asset identity across periods even when both price and volume move significantly.

Table 3.3: Observed vs. derived variables in the valuation chain

Symbol	Meaning	Observed or Derived
S	Physical stock (opening)	Observed: physical asset account
g_t	Natural recharge (net of natural losses)	Observed: hydrological data
q_t	Abstraction/extraction	Observed: metered or estimated withdrawal
$q_{t,net}$	Abstraction net of returns	Derived: q_t minus mandated/voluntary returns (§3.2.3)
R_t	Resource rent per unit	Observed (Tier 1) or Derived (Tier 2, via Options B–F)
F_t	Annual flow value (= $R_t \times q_t$)	Derived: computed from R_t and q_t
V	Stock asset value	Derived: NPV of projected F_t stream (eq. D.2)
p*	Marginal shadow price (= ∂V/∂S)	Derived: theoretical, rarely estimated directly
$\bar{p}$	Harberger approximation ($\frac{1}{2}(V/S_0+V/S_1)$, $\approx V/S_0$ if $\Delta S/S$ small)	Derived: operational proxy for p*
D_t	Depletion charge	Derived: from $\bar{p}$, $q_{t,net}$, g_t (eq. D.5)
Addition_t	Case 3 (under-extraction) stock addition, stored resources	Derived: $\bar{p} \times (g_t - q_t\text{,net})$; zero except Case 3 (§3.6.1, eq. D.6)

Symbol	Meaning	Observed or Derived
OCV_t	Balancing item	Derived: $F_t - (q_t \times \bar{p})$ (§D.2, para. 271)
REV_t	Revaluation (price-level change on unchanged stock)	Derived: from $\bar{p}_{t+1}$ and $\bar{p}_t$ (§3.6.3, eq. D.6)

3.6 Depletion and the Asset Account Reconciliation

This section presents the asset account reconciliation identity that links the water resource stock's opening and closing values (Figure 3.3), and defines the depletion charge that enters the identity.

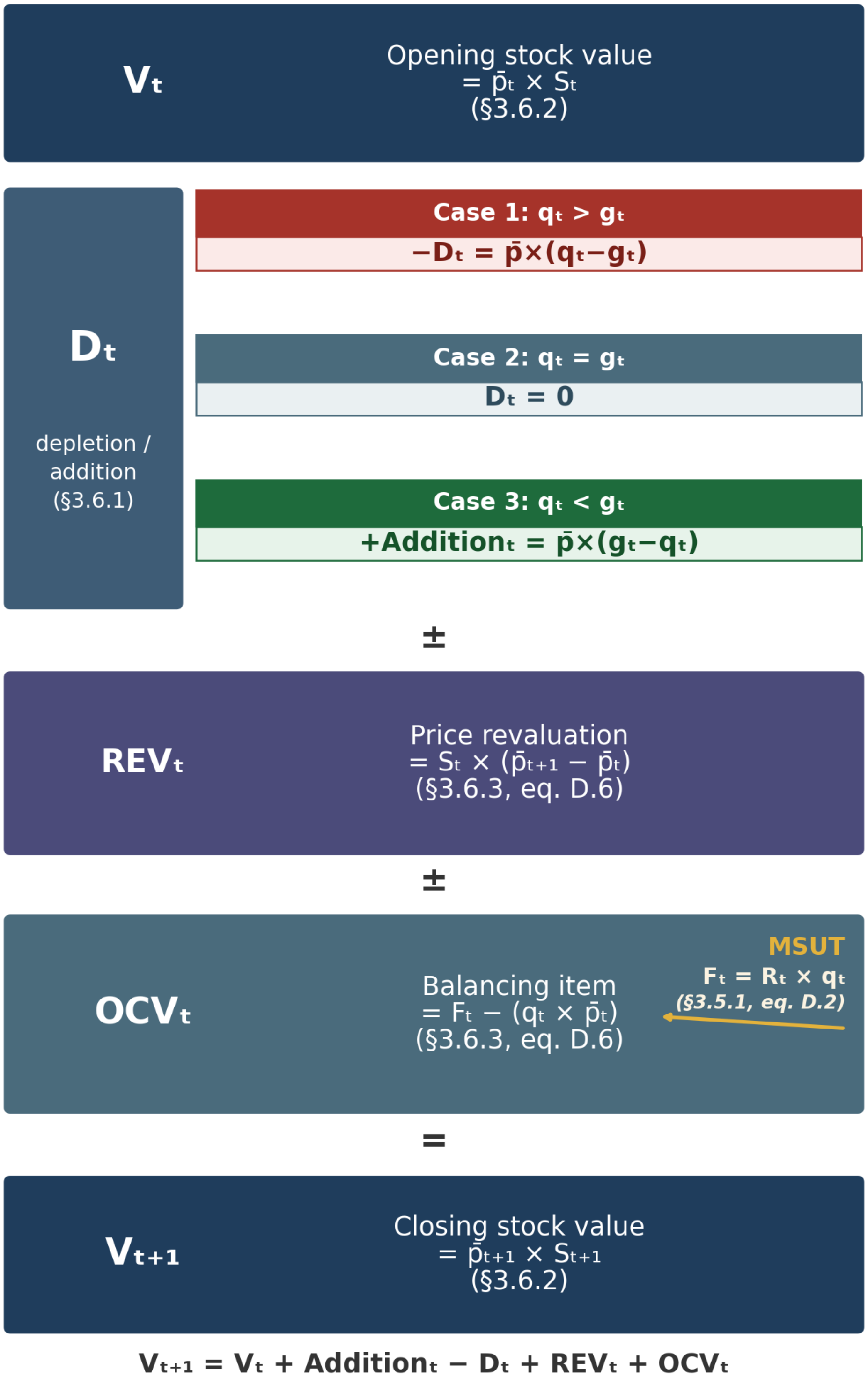

Figure 3.3. Monetary asset account reconciliation (AN.34).

Only one depletion/addition case applies to a given resource type and period. In Case 1 (over-extraction), D_t is recorded as cost of production and reduces NDP; in Case 3 (under-extraction, stored resources only), $Addition_t$ is recorded as both a stock addition and a negative depletion, raising NDP (SNA 2025 §7.288) — this case does not apply to rivers without storage, where surplus flow exits downstream with no entry (§3.6.3). For fossil aquifers and glaciers, where $g_t \approx 0$, $D_t = \bar{p} \times q_t$ (the Case 1 form only). F_t, the resource rent recorded in the monetary supply-use table, is not summed directly into V_t — it enters only as an input to the OCV_t formula. For a fully worked numerical example, see Annex E, Examples 1 and 5.

The accounting identity links opening and closing stock values through depletion, the other changes in volume (OCV_t) balancing item, and revaluation (REV_t); §3.6.3 defines OCV_t, distinguishes it from the physical asset account's own OCV row (Table 3.1), and covers the depletion-charge approximation error (Dgap) as a related but separate memo item. Depletion: $D_t = \bar{p} \times (q_t - g_t)$ for renewable resources; $D_t = \bar{p} \times q_t$ for fossil aquifers where $g \approx 0$. Note the calculation must be repeated for each type of water resource. $\boldsymbol{V_{t+1} = V_t - D_t + OCV + REV}$

3.6.1 The depletion charge

135. The SEEA Central Framework does not define depletion for water as a discrete entry with its own recording rules, the way it treats subsoil assets. This Guidance Note derives depletion for water operationally, through the formulas in this section, because the Central Framework leaves the concept unspecified for this asset class. Compilers should not expect a parallel Central Framework provision to check this treatment against: the definition below is this note’s proposal, not a restatement of an existing standard.

136. The depletion charge D_t measures the reduction in stock value attributable to extraction during the period.[6] It should be calculated separately for each water resource type k (surface water, unconfined groundwater, fossil aquifer) within a river basin, since the sustainable yield condition $q_{t,net} \leq g_t$ differs across types.

137. Three cases arise for renewable resources; fossil aquifers and glaciers are treated separately below.

Renewable resources (g_t > 0), three cases

Case 1: Over-extraction ($q_{t,net} > g_t$):

138. The stock is being drawn down. The depletion charge is:

$$D_t = \bar{p}_t \times (q_{t,net} - g_t)$$

139. This is entered in the production account as a cost of production under SNA 2025, reducing NDP, NNI, and net saving.

Case 2: Extraction at sustainable yield ($q_{t,net} = g_t$):

[6] Losses through distribution leakage (non-revenue water) that return to the river basin do not constitute depletion of the natural stock; losses that reduce usable stock quality or leave the river basin should be recorded in the OCV column.

$$D_t = 0$$

140. The stock is neither growing nor shrinking in principle; no depletion or regeneration entry is required. In practice, exact equality is rarely observed in hydrological data, so compilers should apply a tolerance band (for example, treating $q_{t,net}/g_t$ between 0.95 and 1.05 as sustainable use, following OECD, 2025, §483) rather than testing for exact equality; extraction outside that band should be treated as Case 1 or Case 3 as applicable.

Case 3: Under-extraction ($q_{t,net} < g_t$):D_t

141. No depletion charge arises in the asset account, but the stock grows by ($g_t - q_t$) units during the period. For groundwater and other stored water resources, this physical increase is recorded as an addition, not an OCV entry, in the monetary asset account (§3.6.2); a further, separate production-account entry for stored resources is described immediately below:

$$Addition_t = \bar{p}_t \times (g_t - q_{t,net})$$

142. For flowing surface water without storage infrastructure, Case 3 (under-extraction: $q_{t,net} < g_t$) requires a different interpretation than for groundwater. For groundwater and other stored water resources, the surplus (g − q) increases the physical stock, recorded as an addition in the physical and monetary assetaccounts, and is also recorded as negative depletion in the production and generation-of-income accounts, consistent with the SNA 2025 treatment of regeneration for other renewable natural resources such as fish and timber (§7.288). Negative depletion is a negative cost entry: it raises NDP and net saving in the period it is recorded, the reverse of the depletion charge in Case 1. For a river without storage, by contrast, the surplus exits the territory as downstream flow: no stock addition and no negative depletion should be recorded, since no future extractive benefit is retained within the accounting territory (see §3.6.3). The depletion charge in Case 1 ($q_{t,net} > g_t$) retains its economic interpretation (it represents the shadow cost of reducing the river system's future sustained yield) but compilers should note that for rivers without storage, this situation typically reflects seasonal or sub-annual over-extraction that is masked in annual accounts, or drawdown of a hydraulically connected alluvial aquifer that should be tracked in a separate groundwater account.

143. For groundwater and other stored water resources, this entry raises both wealth, via the addition to the asset account, and income, via the negative depletion entry in the production account described above. That is a different effect than ordinary capital appreciation from price revaluation, which affects wealth only. For rivers without storage, the surplus generates neither entry, as described above. See §3.6.3 for the reconciliation of these entries in the asset account. Note: the SEEA CF depletion charge records only the cost of over-extraction. Sustainable extraction ($q_{t,net} \leq g_t$) generates no depletion charge even though it forgoes the marginal value of additional stock growth; that opportunity cost is economically real but falls outside the exchange-value boundary of the SEEA CF depletion framework.

> ***TC Question 1:*** *Does treating water regeneration as negative depletion, consistent with the SNA 2025 treatment of fish and timber resources (§7.288), appropriately capture the economics of under-extraction? Water differs from fish and timber in that there is no discrete harvest-versus-growth production act: recharge occurs independent of any decision to extract less, which weakens the analogy. Countries are also asked how this treatment should interact with GN D4 Option 3, under which water in large artificial*

reservoirs is treated as a produced asset. Produced biological resources are subject to depreciation and inventory changes rather than depletion and negative depletion, so a reservoir treated as a produced asset under D4 may need a different treatment for regeneration than the depletion-based treatment proposed here for non-produced water resources.

TC Question 2: *Section 3.2.3 defines g_t, net natural recharge, as additions from precipitation and inflows minus natural losses such as evapotranspiration and natural outflow, which lets g_t fall below zero: a drought year can lose more to evaporation than it gains from inflow before any extraction happens. Equation D.5 does not distinguish this from over-extraction. A negative g_t mechanically inflates D_t by the full natural loss, attributing a climate-driven stock decline to the production account as though it were extraction-driven. Hydrological practice keeps recharge and discharge as separate, nonnegative fluxes rather than netting them into one variable that can go negative (Westenbroek et al., 2010; Becke et al., 2024), which points toward routing negative g_t through the other-changes-in-volume line instead of through D_t.*

144. Cases 1 and 2 are two faces of a single function, stated directly in equation D.5: $D_t = \bar{p} \times \max(0, q_t{,}net - g_t)$. The max operator is the switch: above zero it returns Case 1's charge, at zero it returns Case 2's floor. Case 3 falls outside this function: under-extraction produces $Addition_t = \bar{p} \times \max(0, g_t - q_t{,}net)$, a separate positive entry, not a negative D_t — but it draws on the same p̄. Recommendation 8 caps p̄ itself, not just D_t: once extraction approaches stock exhaustion and p̄ exceeds the cost of the cheapest accessible substitute, compilers should use p̄capped = min(p̄, psubstitute) in both formulas, D_t = p̄capped × $\max(0, q_t{,}net - g_t)$ and $Addition_t$ = p̄capped × $\max(0, g_t - q_t{,}net)$. A price too high to be economically defensible for one formula is too high for the other: no rational account should record the marginal unit as worth more entering the stock than it is worth leaving it.

Fossil aquifers and glaciers ($g_t \approx 0$)

145. Where natural recharge is negligible on human timescales, all extraction is depletion and there is no stock-growth case:

$$D_t = (\bar{p}_t \times q_{t,net})$$

Verification

146. The depletion charge should be verified against the physical balance. If the physical account shows $q_{t,net} - g_t$ = 50 million cubic metres, the implied unit price is $D_t \div 50$; if this differs substantially from the independently estimated $\bar{p}_t$, there is a compilation inconsistency requiring investigation. Divergence may also reflect rapid price changes from technology or institutional shifts rather than a measurement error.

3.6.2 The monetary asset account

147. The monetary asset account tracks changes in the value of the water stock across the accounting period:

$$V_{t+1} = V_t - D_t + Addition_t + Revaluation_t + OCV_t$$

148. The opening value V_t minus the depletion charge gives the value after use. Revaluation captures holding gains or losses from changes in the unit price p̄ between periods: if the rent per unit rises, the remaining stock is worth more even without any physical change.

Revaluation is a holding gain; it is not income, and it should not appear in NDP calculations. Revaluation is distinct from a price deflator: it measures holding gains on the water stock in current prices and is not entered in the production or income accounts. The closing value V_{t+1} should be reconciled against an independently estimated value: revalue the closing stock quantity at the closing price and compare. Persistent divergences signal estimation problems in either the price series or the volume series; however, where divergences arise through general equilibrium effects, they may constitute genuine capital gains rather than estimation error.

149. Compilers report each line by resource type, matching the Surface water and Groundwater columns of Table 3.1 (soil water is excluded pending resolution of the open question in Recommendation 1); the Total column sums across types. The account is compiled from the same opening and closing periods as Table 3.1: the physical account establishes S_t and its components, and this monetary account applies the unit price $\bar{p}_t$ (or p^* where estimated) to produce the value entries. Depletion (Case 1) and the under-extraction addition (Case 3) are mutually exclusive within a period for a given resource type; a resource reports one or the other, or neither under Case 2 (sustainable extraction, §3.6.1). Revaluation and OCV are defined in Annex D, equation D.6, and derived in §3.6.3.

Table 3.4: Proposed structure, monetary water resource asset account (AN.34)

Account line	Formula	Surface water	
Opening value (V_t)	V_{t-1}, close[a]		
Additions			
Addition, under-extraction (Case 3, §3.6.1; stored resources only)	$(g_t - q_t) \times \bar{p}_t$		
Reductions			
Depletion charge D_t (Case 1, §3.6.1; eq. D.5)	$\bar{p}_t \times (q_t - g_t)$		
Revaluation REV_t (eq. D.6)	$S_{t,open} \times (\bar{p}_{t+1} - \bar{p}_t)$		
Other changes in volume OCV_t (eq. D.6)	$F_t - (q_t \times \bar{p}_t)$		
Closing value (V_{t+1})	$V_t + Addition_t - D_t + REV_t + OCV_t$		

[a](carried forward; eq. D.6). At initialization, V_t is estimated directly from the NPV of the resource rent flow (eq. D.2), independent of S and $\bar{p}$; $\bar{p}_t = V_t/S_t$ is derived afterward, same as every other period.

3.6.3 OCV Reconciliation, and the Depletion-Charge Approximation Error

150. This OCV reconciliation is needed specifically where a monetary balance sheet is compiled, the SNA 2025 requirement this note supports; compilers working only with the SEEA CF's core supply-use table and physical asset account, without a balance sheet, do not need it. Separately from OCV itself, the depletion charge D_t (eq. D.5) is computed using $\bar{p}$ rather than the theoretically correct p*, and systematically overstates true depletion when $\bar{p}$ > p*, the typical case, since $\bar{p}$ folds in the higher marginal value of units that will only be extracted later, as the stock nears exhaustion, while p* reflects only the current margin, extracted while the stock is still relatively less scarce (§3.5.3). Compilers should disclose this overstatement as a memo item alongside D_t, not as a component of OCV_t. The gap per period is:

$$D_{gap} = (p_t^* - \bar{p}_t) \times (q_{t,net} - g_t)$$

151. When $\bar{p}$ overstates the marginal value (the typical case, per §3.5.3), D_{gap} is negative: the measured D_t exceeds true depletion. Reporting this alongside D_t alerts users to the direction and magnitude of the approximation, without implying it is part of the OCV reconciliation below.

152. D_{gap} is exactly the difference between the true depletion charge and the operational one: Dgap = $D_t(p^*) - D_t(\bar{p}) = p^*(q_{t,net}-g_t) - \bar{p}(q_{t,net}-g_t) = (p^*-\bar{p})(q_{t,net}-g_t)$, confirmed symbolically. It is a property of the depletion charge, not a component of OCV_t. An earlier version of this note conflated the two, claiming this gap was an exact component of OCV_t's own price-substitution error; that claim does not hold under the operational OCV formula given to compilers below ($OCV_t = F_t - q_t \times \bar{p}$): $OCV_t(p^*) - OCV_t(\bar{p})$ works out to $q_t(\bar{p}-p^*)$, a different quantity from D_{gap} in general. OCV_t and D_{gap} are separate, independently useful diagnostics. OCV_t compares observed current-period rent to shadow-priced extraction; D_{gap} measures how much the depletion charge itself overstates true resource loss because it uses $\bar{p}$ rather than p*. Report them as two distinct memo items, never combined or netted against each other. The reconciliation identity (Annex D, equation D.6) defines the operational total OCV using $\bar{p}$, since p* is rarely estimated directly (§3.5.1):

$$OCV_t = F_t - (q_t \times \bar{p})$$

where F_t is the annual flow value recorded in the MSUT (resource rent at the current-period observed price, $R_t \times q_t$) and $q_t \times \bar{p}$ is the Harberger-approximated value of that extraction. The sign of this total OCV term is diagnostically informative: a **positive OCV** ($F_t > q_t \times \bar{p}$) indicates that the current-period rent recorded in the MSUT exceeds the approximated value of the stock, which occurs when current prices are temporarily elevated above long-run scarcity values or when $\bar{p}$ itself understates the stock's long-run value. A negative OCV ($F_t < q_t \times \bar{p}$) indicates that the observed rent is below the value embedded in the asset price, the diagnostic signal for administered pricing that suppresses rent below its scarcity value, and grounds for applying Tier 2 valuation methods (§3.4). This diagnostic reading assumes V has been estimated via the full NPV chain (eq. D.2); under the Annex A constant-rent perpetuity shortcut, OCV_t is persistently nonzero by construction (Annex A, Step 2) and should not, on its own, be read as an administered-pricing signal.

153. The physical asset account's own OCV row (Table 3.1, §3.2.3) captures a different set of entries: reclassifications between surface water and groundwater categories when hydrological understanding improves; catastrophic losses from multi-year droughts that permanently reduce aquifer storage; and revisions to stock estimates when new

hydrological surveys update total recoverable volumes. Each of these should be reported separately in the physical account to allow users to distinguish measurement revision from genuine economic change. This is a distinct quantity from the monetary OCV_t balancing item defined below, which is a single, undecomposed reconciliation entry; the two should not be conflated.

154. For unimpounded flowing surface water systems, a specific OCV entry is required to prevent unabstracted water from being incorrectly recorded as capital accumulation. In any accounting period where natural inflow g exceeds abstraction q, the surplus (g − q), not netted out of g_t itself (§3.2.3), exits the accounting territory via downstream flow to adjacent territories or marine sinks. This water cannot be carried forward as a stock increment. It has physically left the unit. Compilers must record it as a volumetric outflow in the OCV column of the physical asset account, not as an addition to closing stock S_{t+1}. Failure to make this entry will produce an inflated closing stock and a correspondingly overstated balance sheet value, misrepresenting national water wealth. This treatment is distinct from the Case 3 (under-extraction) entry in §3.6.1, which applies to closed or managed systems where surplus water is genuinely retained within the accounting unit across periods.

155. OCV entries should not be confused with revaluation. Revaluation (REV_t) records the change in the value of the stock held at the start of the period, attributable solely to changes in the unit price $\bar{p}$ itself: $REV_t = S_{t,open} \times (\bar{p}_{t+1} - \bar{p}_t)$, where $S_{t,open}$ is the opening stock of period t (equivalently, the closing stock carried forward from the previous period). The opening stock, not the closing stock, is what carries the price change: flows recorded during period t (extraction, addition, OCV_t) are priced separately at that period's own rate, $\bar{p}_t$, and would be double-counted if the stock they created or removed were also swept into the same revaluation gain. Annex E, Example 5, Scenario B, shows why this matters in practice: computing REV_t on the closing stock instead introduces a residual of $\Delta S \times \Delta\bar{p}$ (Int$300 million in that example) that breaks the account's own claim that V_{t+1} minus the physical cross-check equals OCV_t exactly. OCV_t records changes in stock quantity or price-reconciliation adjustments; REV_t records the price-level change on the stock unaffected by those flows. Both entries are necessary for the asset account identity to balance: $V_{t+1} = V_t + Addition_t - D_t + OCV_t + REV_t$, where $Addition_t$ is the Case 3 under-extraction addition (§3.6.1, Table 3.4).

156. GN D7's OCV term, defined above, is a component of the SNA's own other changes in the volume of assets account (K.2), which is broader in scope, covering reclassifications, catastrophic losses, and uncompensated seizures across all asset types. The two should not be treated as synonymous. GN D7's OCV does not include the depletion-charge approximation error (D_{gap}, defined above), which is a separate memo item. Compilers should report GN D7's OCV as a labelled sub-component of the water resource line in K.2, not net it against other K.2 entries for other assets, and should disclose D_{gap} separately alongside it, so neither signal is lost in aggregation. Annex F.4 sets out the reconciliation in full.

3.7 SNA Linkages: NDP, Saving, and the Balance Sheet

3.7.1 Depletion and net domestic product

157. The depletion charge enters the national accounts as an adjustment to net domestic product:

$$NDP_{env} = GDP - Depreciation_t - \Sigma\,(D_t - Addition_t)$$

where Depreciation is the SNA 2025 term for consumption of fixed capital (CFC, in earlier SNA usage), applied to produced assets, D_t is the depletion charge (eq. D.5, floored at zero, §3.6.1), and $Addition_t$ is the Case 3 under-extraction addition for stored resources (eq. D.6, §3.6.1), zero in all other cases. For a stored water resource in Case 3, $D_t = 0$ and $Addition_t > 0$, so the term ($D_t - Addition_t$) is negative, raising rather than lowering NDPenv relative to GDP; the sum runs across all natural resource assets and cases and is not restricted to non-negative terms.

158. Depletion never enters GDP itself. GDP is a production-boundary measure; the depletion charge sits below the GDP line entirely, applied only when moving from GDP to NDP and to the adjusted aggregates in §3.7.2. A country's headline GDP figure is unaffected by water depletion under this framework, whatever the depletion charge's magnitude.

159. This Guidance Note proposes water capital depletion as an explicit component of NDP, consistent with the SEEA CF depletion adjustment. It is not yet established practice under the SEEA CF or the 2025 SNA.

3.7.2 Adjusted net saving and the balance sheet

160. Hamilton and Clemens (1999) showed that adjusted net saving (genuine saving) provides a better measure of change in national wealth than conventional saving rates. The World Bank's adjusted net saving calculations include depletion of subsoil assets and forests; water is not yet included in most country estimates, partly because national water resource accounts are not yet widespread (Lange et al., 2017). Countries that compile water accounts under SEEA CF can contribute water depletion to global genuine saving estimates.

161. The balance sheet entry for water resources (AN.34) records the closing stock value V_{t+1} as calculated in §3.6.2. Where a country's AN.34 entry is declining in real terms over multiple periods, it signals that the water stock is being drawn down and associated future rent flows are being lost. A declining AN.34 entry accompanied by sustained high extraction ratios (q_t/g_t consistently above 1) is a warning of long-term water security risk, expressed in the same units as the rest of the national balance sheet.

3.7.3 What the monetary accounts tell water managers

162. National-level NDP_{env} and net saving are useful for macroeconomic comparisons but too aggregated for water governance. The actionable product is the river-basin-level account: a spatially explicit depletion charge and closing stock value for each major basin or aquifer.

163. A river-basin-level account tells a water manager something the national account cannot. A basin where $\bar{p}$ is rising and the closing stock is falling carries both a physical scarcity signal and a monetary one. A basin where $\bar{p}$ is stable and $q_t/g_t < 1$ is being managed within sustainable yield. These distinctions disappear in national averages (the Modifiable Areal Unit Problem (MAUP) (the statistical artefact whereby results change depending on the spatial unit of aggregation chosen) described in §3.5.3). The accounting architecture in §3.3.2, which starts at the river basin, is designed to produce accounts that water managers can actually use.

164. The river-basin account has a use beyond the balance sheet. Depletion charges and closing stock values, updated annually, function as a scarcity indicator for climate adaptation planning: a basin manager deciding whether to expand reservoir capacity, tighten

groundwater allocation, or set drought contingency triggers needs the signal described above, at this spatial resolution, not a national aggregate. The Murray-Darling Basin water market and the High Plains Aquifer study, both described in Annex C, show what this looks like in practice: basin-level shadow prices that move with scarcity, feeding directly into allocation and investment decisions rather than into a national GDP adjustment. This is the primary channel through which SEEA CF water accounts reach sub-national water managers, and countries compiling river-basin accounts under this Guidance Note should treat that operational use, not the NDP adjustment in §3.7.1, as the main audience for the data.

3.7.4 Institutional Sector Attribution

165. Where the legal owner of a water resource and the unit extracting it are different institutional sectors, a government water authority licensing abstraction to private agricultural or industrial producers, for example, this note follows the split-asset approach SNA 2025 already establishes for mineral and energy resources (2025 SNA, §27.59–27.62): resource rent, and the depletion charge D_t derived from it, are shared between the legal owner and the extractor in proportion to the share of resource rent the owner actually receives as property income. The full depletion charge is recorded first as a cost of production in the extractor's production account, then reallocated through the capital account according to that ratio. Where no rent is paid, the owner's share is zero by default, and the extractor's accounts carry the full depletion charge and the full stock value, a case compilers should flag in metadata since it likely understates the legal owner's wealth.

166. Neither SNA 2025 nor the OECD (2025) compilation guide extends this treatment to water specifically; both are silent on water depletion (OECD, 2025, §97, §101, §202). This note adopts the existing split-asset mechanism rather than proposing a new one, consistent with the position in §1.2 that the gap in water accounting is operational, not conceptual. The full sequence-of-accounts mechanics, including the reallocation through the capital account and the resulting split of stock value across balance sheets, are worked through with a numerical example in Annex F.

3.8 Interface with GN D4: Reservoir Water and Hydroelectric Resources

3.8.1 Reservoir water and D4 Option 3

167. GN D4 addresses the question of whether water in large artificial reservoirs is a produced asset. Under D4 Option 3, the value of stored water is recorded as inventory, a produced-asset category, on the owner's balance sheet, instead of as a non-produced natural-resource entry under AN.34. The two treatments are alternatives, not additive: a reservoir valued under D4 Option 3 is recorded as produced-asset inventory rather than under AN.34, so the same stored water is not counted in both places. The choice of option under D4 does not affect the resource-rent valuation methods this note recommends for water accounted under AN.34.

3.8.2 In-stream uses: hydroelectric generation, thermal cooling, and canal operation

168. Three categories of water use generate economic value without conventional abstraction: hydroelectric generation, thermal cooling, and canal operation. In each case water passes through a facility and returns to the source. The physical stock is not reduced

by the gross flow-through, only by net losses. Despite this non-consumptive character, these uses satisfy the AN.34 in-stream-use test (§3.1, Recommendation 1): an enforceable use right exists, the water generates measurable economic benefit as a productive input, and the use is recorded, or recordable, as a use in the water PSUT. They are accordingly within AN.34 scope. Rouhi Rad et al. (2021) demonstrate directly that hydroelectric water valuation using the production approach falls within SNA and SEEA CF scope; thermal cooling and canal operation are analogous.

169. Only net losses should enter the physical supply-use table as actual use. For hydroelectric generation, net losses include evaporation from reservoir surfaces and operational spill losses; gross turbine flow-through is not use. For thermal cooling, net losses are consumptive evaporation from cooling towers and heated return flows that cannot re-enter the usable stock at the point of return; gross intake volumes are not use. For canal operation, net losses are water irretrievably lost through seepage, evaporation, or discharge beyond the accounting boundary; lock-through volumes that return to the canal are not use. Gross flow-through volumes should be recorded in the main PSUT, consistent with the gross-abstraction convention used elsewhere in this note (§3.2.2), with net use reported alongside so the two figures are not conflated.

170. The productive-value (production function) approach applies directly to all three uses. The resource rent attributable to water is estimated by subtracting payments to all other factors from the value of output: for hydroelectric generation, output is electricity revenue and other factors are capital (dam, turbines), labour, and maintenance; for thermal cooling, output is the cooling service or avoided cost of alternative cooling technology; for canal operation, output is navigation service value. The resulting residual is the water's contribution, expressed as a per-unit flow price and applied via the $\bar{p}$/Harberger methodology in §3.5 to derive both the annual flow value F_t and the stock value V.

171. The classification of in-stream water values in AN.34 is consistent with the asset boundary as interpreted here and is supported by Fenichel et al. (2016) and Rouhi Rad et al. (2021). However, current practice varies substantially: some countries record no AN.34 value for hydroelectric reservoirs; others fold the value into infrastructure assets under GN D4 Option 3; and most do not record thermal cooling or canal water as valued assets at all. The 2028 SEEA CF update needs to resolve this gap explicitly.

This raises GC Question (d) (§5.3).

3.8.3 Classification boundary: AN.34 and AN.32

172. Three asset classes potentially apply to hydropower and related resources under SNA 2025, and their boundaries require explicit guidance to prevent double-counting.

173. *The water resource (AN.34):* The physical water stock available for extraction or in-stream use is an AN.34 natural asset when the asset boundary conditions are met (§2.1). The value of water for hydroelectric, cooling, or canal purposes is an AN.34 value; GN D7's valuation methods apply directly.

174. *Contractual use rights (AN.2):* Under 2008 SNA, a licence to use a natural resource could be recorded separately as AN.2 (specifically AN222, permits to use natural resources), distinct from the underlying resource itself. The 2025 SNA removed this category once natural resources such as hydroelectric potential were recognised as economic assets in their own right: AN222 no longer exists under AN2, and the sole surviving “permission to use” entry, AN392, is reserved for radio spectrum (OECD, 2025,

Measuring Natural Resources in the National Accounts: A Compilation Guide, fn. 42). A licence or concession to operate a hydropower or cooling facility is therefore not separately classified as AN.2 under current guidance; its value is already embedded in the AN.34 water resource and/or the AN.32 energy generation resource to which the licence grants access.

175. *Energy generation capacity (AN.32):* The 2025 SNA classifies renewable energy resources, including the water energy resources of a river system (its sustained flow rate and hydraulic head), under AN322S3 within AN.32 (Mineral and Energy Resources) (OECD, 2025, §4.3). Where this applies, the total value of a hydroelectric site splits between water stock in AN.34 and energy generation capacity in AN.32 (AN322S3). The two components carry different monetary treatments, not only different valuations: AN.34 water resources record extraction as depletion, which enters the production account and reduces NDP, while AN.32 renewable energy resources record both generation and rundown as other changes in volume, which does not. Compilers splitting a hydroelectric site's value between the two categories must apply this different accounting treatment to each component. In practice the split itself remains difficult, and different countries may allocate site value differently without harmonised guidance.

176. The SNA 2025 classification of energy generation capacity under AN.32 alongside the water resource under AN.34 creates a real risk of inconsistent treatment across countries (and of systematic double- or zero-counting of hydropower water resource rent) since AN.34 uses depletion and AN.32 uses other changes in volume for the same underlying site. This issue also intersects with GN D4 dam infrastructure values (§3.8.1). Without coordinated guidance, the 2028 SEEA CF update will embed this ambiguity into national accounts for years. The critical rule is to avoid double-counting across the two classes. Countries should document which class carries the resource rent in their accounts and ensure that summing AN.34 and AN.32 for a given site does not count the same economic value twice.

This raises GC Question (e) and TC Question 3 (§5.3, §5.4).

3.8.4 Other in-stream and non-extractive uses: industrial cooling, navigation, and aquaculture

177. The in-stream-use test in §3.1 and applied in §3.8.2, an enforceable use right, measurable economic benefit as a productive input, and a recordable PSUT entry, extends to three further uses this note has not previously addressed: industrial cooling outside the power sector, navigation on natural (non-canal) waterways, and net-pen or impoundment aquaculture. Each is resolved below by the same test, not left to compiler discretion.

178. Industrial cooling. Process cooling in manufacturing, chemical production, and data centres is structurally identical to thermal cooling for power generation (§3.8.2): water passes through the facility, and only net losses, consumptive evaporation and heated return flows that cannot re-enter the usable stock, constitute use. Where a facility holds an enforceable abstraction or discharge permit, the cooling water is a measurable input to output (manufacturing or service revenue), and the use is recordable in the water PSUT, industrial cooling is within AN.34 scope on the same terms as power-plant cooling, and valued the same way: the production-function approach, output value less payments to other factors, applied via §3.5. Where a facility abstracts water without a permit distinguishing it from general own-account use (§3.3.2), it is captured there instead, as conventional abstraction, not as a separate in-stream case. There is no basis for treating industrial cooling differently from power-plant cooling once the same three conditions are checked.

179. Navigation on natural waterways. Canal operation (§3.8.2) is in scope because an operator holds an enforceable right over channel infrastructure and can attribute navigation service value to that right. Ordinary navigation on rivers and lakes without channel infrastructure is different: it typically operates under a general public right of way, not an enforceable right specific to the water resource, and a shipping operator's costs, fuel, crew, port charges, are payments for infrastructure and services rather than for water. Absent an enforceable use right over the water itself, general river and lake navigation fails the Boundary 1 test and falls outside AN.34, consistent with unlicensed recreational access in §3.4.7. Where a navigation authority does hold an enforceable right, lock tolls on a natural river, reach-specific fairway maintenance charges, licensed dredging concessions tied to a defined channel, the case converges with canal operation and should be valued identically: output is navigation service value, and the residual after other factor payments is the water's contribution.

180. Aquaculture. Pond-based aquaculture draws water through conventional abstraction and is already covered by own-account treatment (§3.3.2); no separate rule is needed. Net-pen and cage aquaculture occupying a demarcated area of a reservoir, lake, or river is a distinct case: water is not abstracted, but a lease or licence grants exclusive occupation of a water body for a production activity, the same non-extractive structure as hydropower and canal operation. Where the lease is enforceable, the water body's contribution to aquaculture output (revenue from fish or shellfish sales) is measurable net of other factors (feed, juveniles, labour, capital), and the occupied area is recordable in the PSUT, net-pen aquaculture is within AN.34 scope, valued via the same production-function approach as §3.8.2.

181. These three cases close the gap between the boundary criteria stated in §3.1 and the boundary cases this note has actually worked through. No new TC question is required: the test that resolves hydropower, thermal cooling, canal operation, and recreation resolves industrial cooling, natural-waterway navigation, and net-pen aquaculture as well, without exception.

4. Recommendations on Conceptual Treatments

182. The following 8 recommendations modernize water accounting by shifting from a rigid, national-level volume approach to a highly granular, economically sound framework. Where consensus exists they are stated as recommendations. Where TC direction is still needed they are stated as proposals for consideration (§5). Final recommendations will not be determined until after the Global Consultation process.

- **Scope and Scale (Rec 1, 6):** Water is tracked at the **river basin level** instead of national averages to prevent mathematical and hydrological errors. Values with no enforceable use right, no SNA-recorded output or measurable access expenditure, and no corresponding use entry in the water PSUT (ecosystem beauty, undocumented existence value) are moved entirely to Ecosystem Accounts (SEEA EA). This boundary tracks documented economic use, not physical consumption: in-stream uses that return water to the source (§3.1) remain within AN.34 where they meet this test.

- **Valuation and Methods (Rec 2, 4, 5):** Establishes a two-tier hierarchy with conditional sub-tier. It acknowledges that standard resource rent calculation fails for water due to artificial pricing, and mandates using market prices, replacement costs, or productivity methods instead.

- **Reconciliation and Quality (Rec 3, 7, 8):** Forces the Supply/Use Tables and Asset Balance Sheets to reconcile using an Other Changes in Volume (OCV) entry. It also requires water quality changes to be documented and, where data allow, reflected as OCV adjustments to the usable stock rather than folded into the depletion charge. It also introduces "valuation at the extremes," capping depletion costs at the price of the cheapest alternative technology (like desalination) so a drying aquifer's calculated value doesn't artificially crash to zero.

183. Readers can explore the accounting implications of Recommendations 2, 3, and 8 interactively (adjusting extraction volume, recharge rate, and substitute ceiling to see how each parameter drives the depletion charge, annual flow value, and OCV reconciliation) at: https://olesonlab.github.io/seea-water-simulator.

Table 4.1: Summary of recommendations

Recommendation	Primary SEEA CF Paragraphs to Revise	Core Accounting Target	Methodological Shift
Rec 1: Scope	§5.11.1–5.11.2, paras. 5.469–5.480 (SEEA CF), 11.203 (SNA 2025)	Monetary Asset Account (**AN.34**)	Defines AN.34 scope with confirmed inclusions (abstraction + productive in-stream uses), confirmed exclusions, and open TC questions.
Rec 2: Targets	5.11.4, New Annex	Balance Sheet (V), MSUT (F_t), Income (D_t)	Explicitly separates stock value from annual flow and depreciation metrics; specifies which target each account requires.
Rec 3: Reconciliation	5.11.4	Balancing Item (OCV)	Mandates joint compilation of MSUT and asset accounts; requires OCV to be reported and interpreted in metadata.
Rec 4 & 5: Method Hierarchy	5.11.4, New Subsection	Monetary Supply-Use Table	Establishes two-tier method hierarchy (Tier 1: observed exchange prices; Tier 2: exchange-value-compatible estimation); explicitly excludes welfare measures from monetary accounts.

Recommendation	Primary SEEA CF Paragraphs to Revise	Core Accounting Target	Methodological Shift
Rec 6: Spatial compilation	§5.11.4, paras. 5.493–5.496	River-basin-level accounts	Requires bottom-up aggregation from river basin $\bar{p}$ estimates to national totals; prohibits estimating national $\bar{p}$ from national-level data directly.
Rec 7: Water Quality	New subsection	OCV quality adjustments	Requires quality documentation and OCV stock adjustment for quality-driven changes; TC question on separate degradation cost.
Rec 8: Extremes	§5.4.3, paras. 5.107–5.108, New Subsection	Depletion Cap (Dt)	Enter zero if water is genuinely plentiful and not being depleted. If the resource is approaching exhaustion, cap the depletion charge at what a substitute technology would cost. Report NA, not zero, if recharge data are missing.

Recommendation 1: Scope of Water Resources (§3.1)

184. It is recommended that the updated SEEA CF provide explicit guidance on the scope of water resources included in monetary asset accounts (AN.34), distinguishing confirmed inclusions, confirmed exclusions, and open questions on which TC direction is sought.

185. **Proposed inclusions:** Surface water (rivers, lakes, and artificial reservoirs) and groundwater (renewable unconfined aquifers and fossil confined aquifers) subject to active abstraction with established and enforceable use rights, and water with established extraction rights but no current abstraction where the value of those rights is observable. Productive in-stream uses (including water for hydropower generation, thermal cooling, and canal operation) are within AN.34 scope because water functions as a direct, measurable input to SNA-recorded outputs in these cases (Rouhi Rad et al., 2021). Compilers should record and value these uses under the water resource asset account.

186. These three activities illustrate a general test, not an exhaustive list: an in-stream or extractive use of a water resource is within AN.34 scope where an enforceable use right exists, the use generates SNA-recorded output or measurable access expenditure, and the use is recorded, or recordable, as a water use in the water PSUT. A lake operated as a paid water park under an enforceable concession, for example, meets this test and is included on the same basis as hydropower. Canal operation meets this test only where the operation itself generates measurable SNA-recorded output, such as navigation tolls; where a canal is purely a conveyance structure moving water to a downstream use with no output of its own, the productive input should be attributed to that downstream use instead, and the canal itself is out of scope. Thermal cooling meets this test only where an enforceable abstraction or discharge permit exists, the cooling water is a measurable input to output, and the use is recordable in the water PSUT; where these conditions are not met, the use falls outside AN.34 scope under Boundary 2 (§5.1) rather than in the confirmed inclusions here.

187. **Proposed exclusions:** Water bodies delivering value exclusively through uses with no enforceable use right, no SNA-recorded output or measurable access expenditure, and no corresponding use entry in the water PSUT do not meet the AN.34 inclusion test and should be recorded in SEEA EA ecosystem service accounts rather than as monetary water resource assets. This exclusion is not a test of physical consumption: 'non-extractive' in this Guidance Note does not mean 'non-consumptive'. Physical accounts should record all water bodies regardless of monetary asset boundary status.

188. Compilers should note that where the stock total S includes water bodies from which no abstraction currently occurs, the derived unit price will understate the resource rent of actively used stocks. To avoid dilution, the unit price estimate should cover only the stock volume from which extraction currently occurs; non-extracted stock components should be excluded from the price computation. The preferred approach is to estimate $\bar{p}$ separately for each resource type k (§3.1) rather than deriving a single national average. This exclusion does not apply to the in-stream productive uses in the preceding paragraph: hydropower, cooling, and canal operation generate SNA-recorded output and belong in the confirmed inclusions.

189. **Open questions: GC direction sought:** The boundary treatment of soil water and of glacier and seasonal snowpack resources in AN.34 is under active consideration (§3.1.3). The open questions are separable: countries can compile complete and internally consistent monetary accounts for the confirmed categories without awaiting resolution of either open question.

190. *SEEA CF paragraphs to update:* §5.11.1–5.11.2, paras. 5.469–5.480 (asset boundary); 11.203 (AN.34 definition, SNA 2025).

Recommendation 2: Valuation Targets (§3.5)

191. It is recommended that the updated SEEA CF distinguish clearly among the three valuation targets for water resources, stock asset value V, annual flow value F_t, and depletion value D_t, and specify which target is required for each accounting purpose: V for balance sheet entries, F_t for the monetary supply and use table, and D_t for net domestic product and net national income calculations. The mathematical relationships among the three targets are specified in Annex D.

192. *SEEA CF paragraphs to update:* 5.11.4 (valuation); new paragraphs for the V–F_t–D_t relationships.

Recommendation 3: MSUT and Asset Account Reconciliation (§3.6.3)

193. It is recommended that the updated SEEA CF require the monetary supply and use table and the water resource asset account (AN.34) to be compiled jointly and reconciled explicitly. The MSUT records water abstraction as a natural input valued at the annual resource rent $F_t = R_t \times q_t$. The asset account values the same extraction at $q_t \times \bar{p}$, the operational proxy for the marginal shadow price of the stock, since p^* is rarely estimated directly (§3.5.1). The balancing item $OCV = F_t - (q_t \times \bar{p})$ must be reported in account metadata with a narrative interpretation; large or persistent OCV entries signal that the F_t and V estimation methods require review for consistency.

194. *SEEA CF paragraphs to update:* 5.11.4 (valuation); new paragraphs for MSUT–asset account reconciliation.

Recommendation 4: Method Hierarchy (§3.4)

195. It is recommended that the updated SEEA CF organise valuation methods in a two-tier hierarchy by proximity to exchange price and data intensity, with a conditional sub-tier within Tier 2 for methods that require specific data conditions to be satisfied. Tier 1 covers methods that directly observe exchange prices: competitive water market prices and the resource rent / net price method where observed prices genuinely reflect scarcity. For most water resources, regulated or zero prices mean Tier 1 methods yield zero or negative rent; Recommendation 5 addresses this case. Tier 2 covers exchange-value-compatible estimation methods.

196. Options without additional conditions: cost-based price substitution (replacement cost), available wherever a credible next-best alternative supply cost can be documented from actual expenditure records, without the narrower eligibility conditions the options below require.

197. Tier 2 Conditional options, eligible when specific data conditions are met: residual value and production function approaches (collectively, productivity-based methods), conditional on water being the binding constraint on output; data-intensive market methods including hedonic pricing, conditional on a competitive property or water-rights market with sufficient transaction volume; and travel cost methods, conditional on the method being used to

recover an exchange-value-compatible access price from observed travel expenditure, without requiring an elasticity estimate to produce the result. Benefit transfer (Option E) sits outside this two-way split: it is not an unconditional option like replacement cost, nor a data-conditional option like the three above, but an interim measure available only where primary estimation under the other options is infeasible, subject to the transfer conditions in §3.4.6.

198. Stated preference methods (contingent valuation, choice experiments, and related approaches) and any travel cost application that produces a consumer surplus estimate contingent on an elasticity assumption are not eligible for any tier of the monetary accounts. These methods measure welfare rather than exchange value and lie outside the SEEA CF monetary account boundary regardless of data quality or study design.

199. Compilers should select the highest tier for which conditions are satisfied, document the method, data sources, and any adjustments made to achieve exchange-value compatibility, and report the tier selected in account metadata.

200. *SEEA CF paragraphs to update:* 5.11.4; new subsection on method hierarchy.

Recommendation 5: Zero and Negative Resource Rents (§3.4)

201. It is recommended that the updated SEEA CF formally acknowledge that the standard resource rent method (extraction revenue minus extraction costs) fails for most water resources because observed prices do not reflect scarcity, and provide explicit guidance on Tier 2 estimation methods as alternatives. Compilers should apply the following approaches in order of preference:

(A) confirm Tier 1 does not apply: even where regulated or zero pricing is typical nationally, a specific resource, basin, or sub-market may still have a competitive water market with prices that demonstrably incorporate resource rent (Recommendation 4, Option A); where it does, apply that price directly rather than proceeding to (B)–(F);

(B) cost-based price substitution (replacement cost), where physical scarcity is established and cost data for credible alternative supply sources are available, valid only where the alternative supply would genuinely be implemented;

(C) residual value or production function approaches, where water is demonstrably the binding constraint on output and produced factor payment data, or sufficient observations to estimate a production function, are available;

202. Where data conditions for (B) and (C) are not met, compilers may additionally consider (D) and (F) where the specific conditions below are satisfied:

(D) hedonic pricing, where a competitive property or water-rights market with sufficient transaction volume exists and water rights are separately identifiable in transaction records;

(F) travel cost methods, where the method is used to recover an exchange-value-compatible access price from observed expenditure data without requiring an elasticity estimate, and the resource supports a productive use with SNA-recorded output.

203. Benefit transfer (Option E) from a documented Tier 1 or Tier 2 source study may be used as an interim measure where primary estimation under any of the above is infeasible, subject to the transfer conditions in §3.4.6.

> ***For TC Consideration:*** *No recommendation is made at this stage on how to operationalize the production approach to stock valuation, adjusted for capital gains and expected stock responses (Fenichel et al., 2016)[7]. This approach derives p* directly from observable rents and stock data without requiring a discount rate assumption. Annex A proposes an interim approach. The TC is invited to assess whether this interim approach is appropriate for inclusion in SEEA CF 2028 guidance. Compilers could use the production approach to derive balance sheet entries, adjusted for capital gains and expected future resource responses.*

204. *SEEA CF paragraphs to update:* 5.11.4; new subsection on method hierarchy (shared with Recommendation 4).

Recommendation 6: Spatial Compilation (§3.2.2)

205. It is recommended that the updated SEEA CF recommend compilation at as fine a spatial scale as data permit, with the river basin as the natural hydrological unit where feasible. National totals should be derived by aggregation from river-basin-level estimates:

$$V_{national} = \Sigma V_k \text{ and } S_{national} = \Sigma S_k$$

The implied national average price $\bar{p}_{national} = V_{national} / S_{national}$ may be reported as a summary statistic for communication purposes, but it is not the estimation target. The estimation target is V_k, and the price it implies, at the river basin level.

206. The correct aggregation sequence is therefore: estimate V_k at the river basin level from the NPV of basin-specific resource rent (eq. D.2), derive $\bar{p}_k = V_k/S_k$, and sum V_k to national totals. The reverse sequence, estimate a single national average price from national stock and rent data and then multiply by national stock, produces an estimate that is neither economically nor hydrologically meaningful, because national average prices suppress the scarcity variation across river basins that makes the accounts useful for allocation decisions. This is a specific instance of the modifiable areal unit problem (MAUP; Addicott and Fenichel, 2019).

207. *SEEA CF paragraphs to update: 5.11.4, paras. 5.493–5.496 (spatial guidance); 5.11.4, paras. 5.488–5.492 (monetary accounts); new paragraph on aggregation sequence.*

Recommendation 7: Water Quality (§3.3.3)

208. It is recommended that the updated SEEA CF provide explicit guidance on how water quality is recorded and reflected in both the physical and monetary water resource accounts. In the first instance, this is a physical-accounting question: compilers should classify water resources into quality classes or grades (for example, by salinity, treatment requirement, or ecological/chemical status) as part of the physical asset account, before any monetary

[7] The capn package (available at https://github.com/ysd2004/capn) operationalizes this approach and is endorsed as a practical reference implementation consistent with Fenichel et al. (2016).

adjustment is attempted. Existing classification systems, such as the EU Water Framework Directive's ecological and chemical status classes, offer one model compilers could draw on or adapt, though this note does not mandate a specific system given its global scope. Compilers should document quality characteristics of the water resources they are valuing.

209. Where quality data are sufficient to support adjustment of the usable stock volume S or the resource rent F_t, those adjustments should be made and the method documented. Quality-driven reductions in usable stock should be recorded as other changes in volume (OCV) in the asset account, distinct from the depletion charge, which records only quantity extraction in excess of recharge. This distinction matters because depletion is a cost of production entered in NDP calculations, while OCV quality adjustments are balance-sheet revaluations that do not enter NDP.

210. *SEEA CF paragraphs to update: new subsection on quality classification (physical account) and quality adjustment (monetary accounts).*

Recommendation 8: Valuation at the Extremes (§3.4, §3.6.1)

211. It is recommended that the updated SEEA CF acknowledge three distinct situations in which the standard resource rent method produces extreme or theoretically problematic values and provide explicit guidance for each.

212. First, where extraction from a water resource approaches stock exhaustion, the applicable charge should be capped at the unit cost of the cheapest available substitute water supply technology that is realistically accessible to users of the resource at scale: the depletion charge D_t in Case 1, and the addition entry Addition_t in Case 3, wherever $\bar{p}$ is inflated for the same reason (§3.6.1). This substitute ceiling (equivalent to the Option B (replacement cost) estimate applied as an upper bound) resolves the zero problem in exchange-value terms: the marginal value of the last unit of a depleting aquifer cannot exceed the cost of the substitute, because rational users would switch to the substitute before paying more, and by the same logic, a unit of stock recovery should not be valued above what it would have cost to secure the same water from the substitute. Where no credible substitute exists at any accessible cost, compilers should document this as a data limitation and flag the depletion or addition estimate as unreliable.

213. Second, where resource rents are zero owing to hydrological abundance rather than administered pricing failure, zero depletion is the correct entry and Tier 2 method substitution is not required. Hydrological abundance is indicated where natural recharge g_t substantially and persistently exceeds extraction q_t at the river basin level, there is no evidence of unsatisfied demand or rationing, and independent physical evidence confirms the resource is far from any binding constraint. This case is distinct from the zero-rent case addressed in Recommendation 5, where zero observed prices reflect institutional failure rather than physical abundance.

214. Zero depletion indicates sustainable extraction, not the absence of asset value: the two are distinct concepts, since D_t measures a flow (extraction relative to sustainable yield in the current period) while V measures a capitalized stock (the present value of expected future resource rents). Where the resource carries a positive shadow price despite $D_t = 0$ (for example, a sustainably managed but still-scarce aquifer) V remains positive and should be

reported as such. V approaches zero only where the underlying resource rent itself is zero, as in the genuine-abundance case described above, not merely because depletion is zero.

215. Third, where recharge data g_t are unavailable, compilers should report D_t = NA rather than zero. A missing recharge estimate is not evidence of zero depletion; reporting NA preserves the distinction between a confirmed zero and a data gap.

216. *SEEA CF paragraphs to update:* new subsection on valuation at the extremes; update to §5.4.3, paras. 5.107–5.108 (written-down replacement cost method), for the substitute-ceiling treatment.

5. Other Considerations in Advancing the Issue

5.1 Beyond exchange values

217. The policy questions that motivate water resource accounts cannot all be answered using exchange value alone, but the most fundamental sustainability question (is national wealth non-declining, accounting for the drawdown of water capital?) can be answered directly from the exchange-value accounts: V measures the contribution of water stocks to national wealth, and D_t measures the rate at which that wealth is being consumed (Fenichel, Obst and Wentland, 2024).

218. Water resource monetary accounts are organised around four accounting boundaries, consistent with emerging national practice in natural capital accounting (Vardon et al., 2025; Warnell et al., 2020) and with Recommendation 1 of this note (spatial compilation guidance is addressed separately in Recommendation 6).

219. Boundary 1, the SNA production boundary: water resources are within the scope of AN.34 monetary accounts where water enters productive processes that contribute to SNA-recorded output, including market activities and own-account abstraction. This boundary is aligned with SNA 2025, which establishes water depletion as a cost of production, and provides the foundation for compiling resource rent, depletion, and the asset account.

220. Boundary 2, non-market services beyond the SNA production boundary: water resources that increase welfare or wellbeing through non-market services, including access for unpaid recreational uses and productive uses such as industrial cooling where these are not captured under Boundary 1, fall beyond the SNA production boundary. Industrial cooling is resolved by the same in-stream-use test applied throughout this note, not by discretion: it falls in Boundary 1 where an enforceable abstraction or discharge permit exists, the cooling water is a measurable input to output, and the use is recordable in the water PSUT, and in Boundary 2 otherwise (§3.8.4). These values are appropriate for supplementary accounts and Complementary Account Network (CAN) tables.

221. Boundary 3, spiritual and non-use values: water resources that generate spiritual, cultural, or non-use values, including existence and bequest values, are aligned with SEEA-EA Cultural Services accounts. These values are not recordable in AN.34 monetary accounts but are appropriate for SEEA-EA ecosystem service accounts and may inform supplementary reporting.

222. Boundary 4, physical flows without a monetary boundary: physical water flows that do not cross any monetary boundary, including environmental water allocations, ecological base flows, and other flows tracked in the SEEA-Water Physical Supply-Use Table (PSUT) but not associated with abstraction rights or market use, are recorded in physical accounts only. These flows are essential for the integrity of the PSUT and for tracking hydrological sustainability, but they do not generate a monetary entry in AN.34. Compilers should ensure that physical flows are fully reconciled in the PSUT before applying any monetary layer.

223. Valuation at the extremes of stock exhaustion and hydrological abundance, where standard exchange-value methods break down or produce degenerate results, is addressed separately in Recommendation 8.

224. Beyond inclusive wealth — a genuine-saving measure extended to incorporate ecological and economic resilience (Walker et al., 2010) — there are policy questions that exchange value alone cannot answer, including questions about welfare losses, social costs of depletion, and investment cases for river basin protection. The SEEA CF cannot incorporate welfare values into its monetary accounts. But the accounts can provide a structured pathway for presenting welfare estimates alongside exchange-value entries via bridge tables. Compilers may present water resource values at three levels.

225. The exchange-value floor is the entry recorded in the monetary supply-use table and asset account, estimated using Tier 1 or Tier 2 methods (Options A–F, Recommendation 4). The partial zone covers estimates that recover a component of exchange value but commingle it with welfare surplus without clean separation, such as surplus-based travel cost estimates or stated preference applications that attempt to isolate a use-value component; these are not eligible for the monetary accounts but may be reported in bridge tables alongside the monetary account entry, with clear labelling of the methodological basis and the welfare component included.

226. The welfare-value ceiling covers total economic value estimates from stated preference studies (contingent valuation, choice experiments), which measure willingness-to-pay inclusive of consumer surplus; these are legitimate inputs to Complementary Account Network (CAN) tables and are appropriate for policy analysis where total economic value is relevant, while remaining excluded from monetary supply and use tables.

227. The bridge table makes the relationship among the three levels explicit and allows users to understand what the monetary account entry does and does not capture without conflating exchange value with welfare value. Countries with existing stated preference datasets are encouraged to report CAN tables using the bridge table format as a transparency measure, not as a substitute for Tier 1 or Tier 2 monetary account entries.

228. One further editorial action is proposed for the SEEA CF 2028 update: acknowledge explicitly that exchange-value water accounts capture a subset of water's economic and social importance. In contexts where non-monetary indicators, governance metrics, or narrative accounts serve as the primary representation of water's value, the SEEA CF should document the governance framework and the reasons monetary valuation was not applied or was applied only partially.

5.2 Areas requiring additional support

229. This guidance note establishes the valuation framework and method hierarchy but does not provide step-by-step compilation procedures. Accountants implementing these recommendations will require dedicated support in the following areas:

- Data collection protocols for supply industry cost accounts (Option B, §3.4.3), including treatment of cost categories that vary across utility structures.
- Procedures for applying productivity-based methods (Option C, §3.4.4) at river basin and sector level, with templates for data requirements.
- Definition and delineation of accounting river basins, including treatment of transboundary aquifers and shared surface water bodies.
- Procedures for applying the interim NPV approach in Annex A, including sensitivity testing for discount rate and projection period assumptions.
- Protocols for documenting quality adjustments to usable stock estimates, and for reporting when quality data are insufficient.
- Procedures for compiling the MSUT and asset account jointly, computing the OCV balancing item, and documenting its sign and magnitude in metadata.

5.3 GC Questions for global consultation

230. The following GC Questions are designated for the global consultation period before the 2028 SEEA CF update. Countries should report current treatment and comments to the SEEA Secretariat by the deadline specified in the consultation schedule.

> ***GC Question (a):*** *Does your country currently record reservoir waters separately from lakes in the physical asset account? (§3.1.1)*
>
> ***GC Question (b):*** *Should soil water be in scope of valuation? (§3.1.3)*
>
> ***GC Question (c):*** *Should glaciers and seasonal snowpack be in scope of valuation? (§3.1.3)*
>
> ***GC Question (d):*** *Does your country currently record an AN.34 value for hydroelectric reservoirs, thermal cooling water, or canal operation water? If so, which valuation method is used and what data sources are drawn on? If not, what barriers (conceptual, legal, or data) prevent compilation? (§3.8.2)*
>
> ***GC Question (e):*** *Does the AN.32 (AN322S3) classification for hydroelectric generation capacity in SNA 2025 affect how your country currently reports or plans to report hydroelectric water resources? (§3.8.3)*
>
> ***GC Question (f):*** *Discount rate in practice. §3.5.2 recommends using a risk-free rate consistent with national accounts practice, with the cost of long-term government debt adjusted for expected inflation as one operational approach. Do countries currently follow this, and what specific rates are used? Do any countries use a social discount rate instead? Is a bounded recommended range (e.g., 2–5%) preferable to country-specific discretion? (§3.5.2)*

5.4 TC Questions

The following six questions require a decision by the Technical Committee rather than broad country input, and are addressed to the TC directly rather than being part of the formal global consultation period above.

> ***TC Question 1:*** *Regeneration and negative depletion. Does the treatment proposed in §3.6.1 appropriately capture the economics of under-extraction, and how should it interact with GN D4 Option 3? (§3.6.1)*
>
> ***TC Question 2:*** *Negative net natural recharge. §3.2.3 defines g_t as net natural recharge, additions from precipitation and inflows minus natural losses such as evapotranspiration and natural outflow, which allows g_t to fall below zero in a drought year independent of any extraction. Equation D.5 does not distinguish this from ordinary over-extraction: a negative g_t mechanically inflates D_t by the full natural loss, attributing a climate-driven stock decline to the production account as if it were extraction-driven. Hydrological estimation methods do not net recharge and loss into a single signed variable this way. The USGS SWB model floors recharge at zero and tracks water deficits separately as reduced actual evapotranspiration (Westenbroek et al., 2010), and the water table fluctuation method's apparent negative-recharge readings are conventionally read as crossing into discharge or as a specific-yield estimation artifact rather than as recharge running backward (Becke et al., 2024; Crosbie et al., 2019). Should negative g_t instead route through the physical and monetary other-changes-in-volume line (§3.2.3), leaving D_t to capture only extraction beyond whatever recharge actually occurred? (§3.2.3, §3.6.1)*
>
> ***TC Question 3:*** *What changes, if any, are needed in GN D7 guidance to ensure consistent treatment across AN.34, AN.32, and GN D4 infrastructure values? Specifically, which class should carry the resource rent, and should an additive framework summing to total site value without overlap be mandated? (§3.8.3)*
>
> ***TC Question 4:*** *Should the updated SEEA CF introduce a monetary degradation cost for water quality loss, separate from depletion and from OCV stock adjustments? (§3.3.3)*
>
> ***TC Question 5:*** *SNA asset-boundary test for water. This note follows the traditional SEEA CF convention that its monetary scope equals the SNA's: any water resource within the proposed AN.34 boundary is treated as meeting the SNA's economic-asset criteria (enforceable ownership or use rights, and expected future economic benefit to the owner) by definition. That correspondence has not, to the authors' knowledge, been rigorously tested against SNA criteria for water resources specifically, as it has for other environmental assets with longer-established SNA treatment. Does the TC agree that the water resources within this note's proposed AN.34 scope (§3.1, Recommendation 1) satisfy the SNA 2025 economic-asset test in practice, or is additional guidance needed on how that test applies to water? A specific part of that question: since enforceability of use rights is set by the domestic water-rights regime and varies by jurisdiction, and sometimes within one (§2.1), does the SNA test need guidance on how to apply it across riparian, prior-appropriation, permit-based, and communal or customary regimes, or is that a matter for country-level judgment? (§1.3, §2.1, §5.5 priority 8)*

> ***TC Question 6:*** *Institutional sector attribution for water. §3.7.4 and Annex F extend SNA 2025's split-asset approach (§27.59–27.62) to water, sharing depletion and stock value between the legal owner and the extractor in proportion to the owner's share of resource rent received. That ratio is observable where a licence fee or royalty is paid. It is not where water rights are held communally or under customary tenure without a single identifiable legal owner, or where ownership is shared across national, state or provincial, and river-basin authorities. Does the TC agree the split-asset approach should extend to water on these terms? How should compilers determine the ownership share for attribution when no rent is observed, and what should the default be when it cannot be determined at all? (§3.7.4, Annex F)*

5.5 Methodological priorities for the 2028 update

231. Eight methodological issues require resolution before the 2028 update to produce guidance sound enough for widespread implementation.

1. Own-account abstraction. Most countries lack comprehensive metering and monitoring infrastructure (though metering is well-established in jurisdictions with active water markets, such as the Murray-Darling Basin and the western United States, and satellite-based remote sensing increasingly supplements direct measurement) to track own-account agricultural abstraction at the spatial and temporal resolution the accounts require.

However, physical data from remote sensing (including satellite-based evapotranspiration estimation and radar-based soil moisture mapping) are improving rapidly, offering a validated path toward closing the abstraction gap without requiring universal physical metering infrastructure (Filippelli et al., 2022; Karimi et al., 2015). A priority is a review of current remote sensing practice and the conditions under which it produces volumes reliable enough for national accounting.

The World Bank's global feasibility assessment for water valuation across 150 countries identified the same gap as a structural obstacle: own-account water abstraction by agriculture, mining, and energy is theoretically within the scope of the SNA but in practice is not recorded as an input to production, so the value of water to these industries is systematically underestimated in any resource rent calculation (Vardon, 2024). Resolving the abstraction gap is therefore a prerequisite not only for this Guidance Note but for the broader agenda of embedding water as a natural capital asset in national wealth accounts.

The data challenges associated with own-account abstraction are reviewed comprehensively in Vardon, Oleson and May (2024), which surveys national practice across twelve countries and identifies metering infrastructure gaps, reliance on modelled abstraction estimates, and the limited use of remote sensing as the three most binding constraints on compiler capacity. The review also identifies Australia and the Netherlands as leading cases where administrative data and metered abstraction records together support reliable Tier 1 price estimation.

2. **Spatial disaggregation.** National $\bar{p}$ estimates produce accounts that cannot support river-basin-level governance. Priorities include methodological guidance on river-basin-level price estimation and worked examples from countries with operational river basin accounts. Australia's National Water Account provides the clearest model currently available (Bureau of Meteorology, 2024b).

3. **Water quality classification.** Current AN.34 and SEEA-Water guidance does not differentiate by water quality; a cubic meter of pristine alpine stream water and a cubic meter of brackish groundwater carry starkly different resource rent values but appear as equal volumes in the standard PSUT. While the SEEA Ecosystem Accounting (SEEA EA) framework introduces biophysical tracking via Ecosystem Condition Accounts (UNSD et al., 2024; Baltranaitė, 2025), a localized pricing framework remains a noted gap. Priorities include methodological guidance on quality-differentiated asset classification (e.g., standardizing bins by salinity or treatment requirements), operational workflows to map these to distinct resource rent estimates, and guidance on when and how to apply quality classification.

4. **Price estimation at extremes.** The residual value method is sensitive to the assumption that water is the binding constraint on output. At very high extraction rates, scarcity creates general equilibrium effects that a sector-level residual cannot capture (Fenichel and Abbott, 2014). A priority is guidance on when partial equilibrium price estimation is adequate and when general equilibrium approaches are required, with empirical benchmarks.

5. **Harberger approximation and reporting guidance.** The framework designates $p^* = \partial V/\partial S$ as the conceptual standard for water capital valuation, with $\bar{p} = V/S$ as a Harberger approximation valid when $\Delta S/S \approx 0$. For stressed water bodies where stock changes are significant, the approximation introduces material error. Priorities include criteria for when $\bar{p}$ adequately proxies p^*, how to quantify and disclose approximation error in metadata, and a transition pathway toward routine direct estimation of p^*. Reas et al. (forthcoming) confirm that not one of 61 exchange-value-compatible observations in a PRISMA 2020 meta-regression directly estimates V (all estimate F_t) underscoring the universality of the gap and the urgency of standardising the $F_t \rightarrow V$ approximation.

6. **Production approach to stock valuation.** Fenichel et al. (2016) propose deriving p^* directly from observable resource rents and stock dynamics, without a discount rate assumption. Annex A outlines an interim operationalization. A key methodological priority for 2028 is to assess whether this approach can be validated at scale using available national data, and whether it should be incorporated into GN D7 as an alternative to the Harberger approximation (see also GC Question (f) on discount rate practice).

7. **Temporal and spatial resolution of the depletion charge.** The multi-year averaging in §3.2.3 assumes annual compilation as the base frequency, but basins with strong seasonal draw-down and refill cycles may need sub-annual data to avoid masking within-year overdraft that self-corrects by year-end. A sustained multi-year gap between extraction and recharge, rather than a single dry year, is what that averaging is already designed to catch. Whether summing depletion across time (multi-year totals) or space (national totals aggregated across river basins) produces a policy-relevant number, rather than an artifact of combining heterogeneous hydrological units, has not been tested. TC guidance is needed on minimum resolution requirements and on whether aggregate depletion totals should be reported at all, or only disaggregated by basin and period.

8. **Institutional and legal determinants of enforceability and market availability.** This note treats "enforceable use right" (§2.1, Recommendation 1) as a condition compilers check, without addressing that what counts as enforceable, and whether the right is quantified or transferable, is set by the water-rights regime in force, riparian, prior

appropriation, permit-based, or communal and customary tenure, and that regime can vary within a single country as well as across countries (§2.1 gives the U.S. riparian/appropriation split as an illustration).

The consequence reaches further than scope: it is a large part of why Tier 1 market evidence exists in some jurisdictions and not others (§3.4.2), and it bears directly on the institutional-attribution questions already raised in §3.7.4, Annex F, and TC Question 6 for communal and customary tenure specifically. A full treatment would need to survey water-rights regimes across roughly 190 country contexts, which this note does not attempt and which may not belong in a valuation guidance note at all. An open question is how much of this the 2028 update should address directly, versus flagging as context compilers must establish locally before applying §3.4's method hierarchy.

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Annex A: Interim Approach to Estimating Stock Asset Value from Annual Flow Values

232. Each valuation method in §3.4 gives F_t, the exchange price of water taken out in a given year. National balance sheets need V, the stock value. V is the present value of future resource rents. This annex gives a four-step interim method. Countries can use it to make balance sheet entries and depletion estimates. The TC continues to review discount rates and rent projections.

Step 1: Estimate F_t using the method hierarchy in §3.4

233. Apply the highest-tier method with enough data. Use Tier 1 if possible. Use Tier 2 only under stated conditions. Do not use Tier 3 for monetary accounts. Document the method, the data sources, and all adjustments for exchange-value compatibility.

234. Reas et al. (forthcoming) give the most complete review of F_t estimates. Their meta-regression method finds 61 exchange-value-compatible results from 18 countries. None of these results estimate V directly. For this reason, compilers cannot skip the F_t to V conversion in Steps 2 to 4, even when annual flow unit prices are reliable.

235. **WARNING: Perpetuity Method Inapplicable to Fossil Aquifers and Structurally Declining Systems.** Do not use the perpetuity formula $V = F_t / r$ for fossil aquifers or for water systems in steady decline. This formula assumes a constant resource rent F_t and a stock that lasts forever. Two cases break this assumption:

236. Case 1: Fossil (confined) aquifers with almost no recharge on a human time scale. All extraction is permanent depletion and the stock is finite. The perpetuity formula will overstate the asset value V and overstate the depletion charge D. Use the finite-horizon NPV formula instead:

$$V = \Sigma_{t=1}^{T} F_t / (1 + r)^t \quad \text{where } T = S / q$$

237. Update T in each period as S changes. See Example 2 in Annex E.

Case 2: Renewable resources in steady decline, where continued over-extraction has reduced hydraulic head or year-to-year recharge rates. Even when recharge g is more than zero, the constant-rent assumption does not hold. Project a declining rent path. Apply a discounted NPV over the projection period. Record a sensitivity analysis.

238. If compilers do not apply this restriction, national wealth for aquifer-dependent economies can be overstated.

Step 2: Approximate V using the constant-rent perpetuity formula

239. If compilers assume that future resource rents stay at the current level, the present value of a perpetual stream at discount rate r is:

$$V \approx F_t / r$$

240. This formula gives a lower bound if resource rents are expected to rise, as in a fossil aquifer depletion scenario. It gives an upper bound if rents are expected to fall, as in a

currently abundant river basin. Record both types of bias. Because this shortcut estimates V independently of S, the derived $\bar{p}$ = V/S will generally differ from R_t itself even absent any genuine scarcity or administered-pricing signal; compilers should expect $OCV_t = F_t - (q_t \times \bar{p})$ (§3.6.3) to be persistently nonzero under this approximation for that reason alone, and should not treat a nonzero OCV_t here as evidence of administered pricing without further investigation (Annex E, Examples 1 and 5). For fossil confined aquifers with a finite depletion horizon T = S/q, compilers can use the finite-horizon annuity formula instead. Use the same four-step procedure, with T in place of the perpetuity assumption.

Step 3: Derive unit price p

241. The Harberger approximation is $\bar{p} = ½(p_a + p_b)$. This averages the unit price at the opening stock ($p_a = V/S_0$) and at the projected closing stock ($p_b = V/S_1$, where $S_1 = S_0 + g_t - q_t$). If the stock change ΔS/S is small (§3.5.4), the difference between p_a and p_b is small. In this case, compilers can use the simpler form $\bar{p} \approx V/S_0$. Record this simplification in metadata. In both cases, use the usable opening stock S_0 from the physical asset account. Exclude stock components with no SNA-recorded output (see Recommendation 1). Apply the depletion formula. For renewable resources, $D_t = \bar{p} \times \max(0, q_t\text{,net} - g_t)$; where q_t,net < g_t, the surplus is recorded as Addition_t in the asset account; for stored resources (groundwater, reservoirs) it is also recorded as a negative depletion entry of equal magnitude in the production account, but for unstorable flowing water neither entry is recorded (§3.6.1, eq. D.5). For fossil aquifers where $g_t \approx 0$, $D_t = \bar{p} \times q_t$,net. If g_t is not available, report D_t = NA. Do not report zero. A missing recharge estimate is not proof of zero depletion (Recommendation 8; Annex D, equation D.5, case iii). As S falls toward exhaustion, the gap between $\bar{p}$ and p* grows. The depletion charge becomes more overstated. Compilers should flag any period approaching or exceeding the §3.5.4 threshold for review, and expect the divergence to widen well beyond it as a fossil aquifer nears exhaustion (Annex E, Example 4, where ΔS/S reaches 31%).

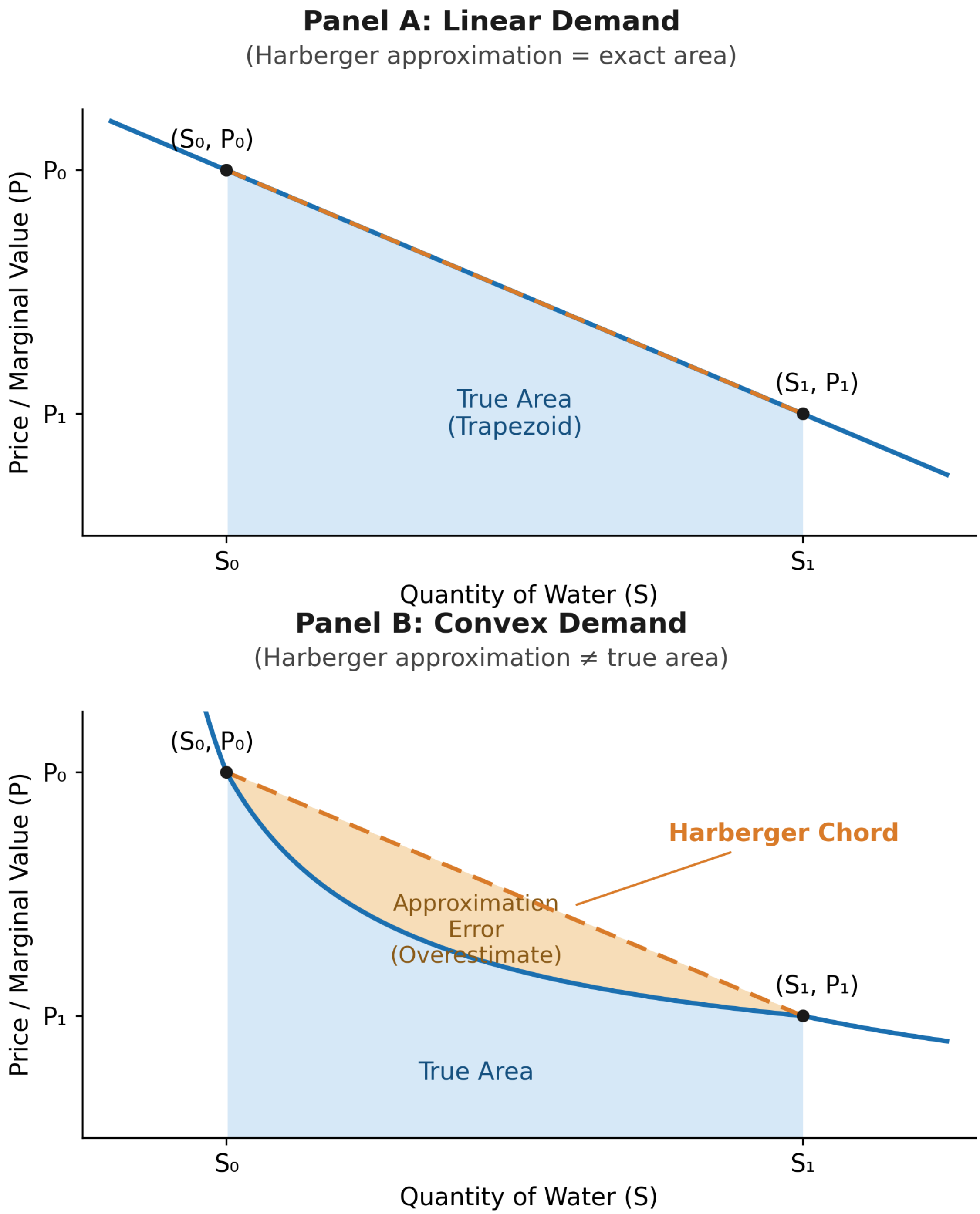

Figure A.1. The Harberger approximation uses the trapezoid formed by connecting two points on the demand curve with a straight chord (dashed line). Under linear demand (Panel A) this is exact. Under convex demand (Panel B) the chord lies above the true curve, causing the approximation to overestimate the true welfare area. The magnitude of the error grows with the degree of curvature and the distance between S_0 and S_1.

Figure A.1. Harberger approximation geometry and valuation error.

The Harberger approximation uses the trapezoid formed by connecting two points on the demand curve with a straight chord (dashed line). Under linear demand (Panel A) this is exact. Under convex demand (Panel B) the chord lies above the true curve, causing the approximation to overestimate the true welfare area. The magnitude of the error grows with the degree of curvature and the distance between S_0 and S_1. (§3.5.3, Recommendation 2)

Step 4: Report assumptions and sensitivity

242. For each compilation, metadata must record five items. First, the discount rate r and its justification. Second, the projection assumption: perpetuity or finite horizon. Third, the direction of bias that the formula introduces. Fourth, the sensitivity of V and D_t to a range of r, at minimum r minus 1 percentage point and r plus 1 percentage point. Fifth, the quality of the underlying F_t estimate. The TC can assess whether this interim approach fits SEEA CF 2028 guidance. The TC can also direct the next phase of work on discount rate and projection method.

Supplement to Annex A: Fenichel Production Approach, Interim Operationalisation

243. The four-step procedure above derives V from F. It assumes a discount rate r (V = F/r). Fenichel and Abbott (2014) propose a different method, applied to groundwater by Fenichel et al. (2016). Their method anchors the stock value to current, observable production data and the physical depletion rate. It does not assume a discount rate. This supplement gives an interim version of their method. It uses the worked example parameters from Annex E, Example 1 (S_0 = 500 km³, q = 10 km³/yr, g = 8 km³/yr, R = Int$0.50/m³).

244. Step P1: Compute the net depletion rate. From the PSUT, derive $\delta = (q_t - g_t) / S_t$. δ is the fractional drawdown of the stock per year. For the worked example: δ = (10 − 8)/500 = 0.004/yr. The aquifer loses 0.4% of its stock per year.

245. Step P2: Estimate the production-based stock value. Apply $V_{production} = F / \delta = F \times S / (q - g)$. F is the annual flow value from Step 1. For the worked example: $V_{production}$ = Int$5,000 million / 0.004 = Int$1,250,000 million. This equals the total undiscounted future value at current extraction rates. The aquifer will last S/(q − g) = 250 years. So $V_{production}$ = F × 250 years. The production approach sets the social discount rate to zero.

246. Step P3: Derive the unit shadow price: $p^*_{production} = V_{production} / S = R \times q / (q - g)$. For the worked example: $p^*_{production}$ = 0.50 × 10/2 = Int$2.50/m³.

247. Step P4: Compute the depletion charge. $D_{production} = p^*_{production} \times (q_t - g_t) = R \times q_t$. For the worked example: $D_{production}$ = 2.50 × 2 km³ = Int$5,000 million/yr. Note that $D_{production}$ = F, the total annual rent. The production approach treats every unit of net over-abstraction as a withdrawal of capital at full rent value. By contrast, $D_{standard} = \bar{p}_{standard} \times (q_t - g_t)$ = 0.25 × 2 km³ = Int$500 million/yr = F/10.

248. Sensitivity. For the worked example, the ratio $V_{production} / V_{standard} = r / \delta$ = 0.04 / 0.004 = 10. This ratio equals 1 when r = δ. For large, slowly depleting aquifers, where δ is much less than r, the production approach gives much higher values. For fossil aquifers near exhaustion, where δ is large, the two approaches converge.

249. Compilers using the production approach must do four things. First, confirm that R is the full resource rent, net of all extraction costs. Second, report $V_{production}$ alongside $V_{standard}$, with

the ratio $V_{production}/V_{standard}$ in metadata. Third, note that the production approach assumes zero social discounting. Fourth, flag that $D_{production} = F$ can have a large effect on NDP. The TC can assess whether the production approach, or a mix of the production and discount-rate approaches, gives the best basis for SEEA CF 2028 stock valuation guidance.

Annex B: Water Classification Concordance Across Frameworks

250. Table B.1 maps water resource classifications across the SNA 2025, SEEA-Water 2012, SEEA CF 2012, and SEEA EA 2021. The table identifies where classifications align directly, where they differ in detail, and where gaps exist that are relevant for compiling monetary water resource accounts.

Methodological & Structural Notes

251. **Artificial Reservoirs Recording Practice:** SEEA CF and SEEA-Water do not resolve whether reservoir waters should be recorded separately from lakes in the physical asset account, though both include reservoirs in the physical asset account (Table 5.25). This is a classification and recording-practice question, distinct from the produced/non-produced asset boundary question addressed in **GN D4 Option 3** (§3.8.1). Current country practice is sought via GC Question (a) (§5.3).

252. **Soil Water Boundary:** Soil water is notably absent from the **SEEA EA (2021)** ecosystem asset classification and **SNA 2025** monetary accounts, though it appears in physical terms in the Central Framework. The boundary treatment in **AN.34** monetary accounts remains an open question referred to the Technical Committee (TC) regarding whether it functions as a standalone environmental asset or part of an ecosystem service.

253. **Glaciers & Snowpack Inconsistencies:** No framework provides explicit monetary asset account guidance for glacier and seasonal snowpack resources. Physical account stock measures are highly inconsistent across national implementations. The baseline question of exactly when meltwater crosses the environment-economy boundary is referred to the TC.

254. **Desalinated Water Circularity Warning:** Because desalinated water is structurally classified as a **product (CPC 1800)** rather than an environmental asset stock, using desalination cost as a valuation benchmark while simultaneously tracking it as a stock increment introduces a conceptual circularity. This risk must be explicitly flagged in compilation metadata when implementing Option B valuation methods.

255. Comisari and Vardon (2013) provided an early synthesis of the conceptual issues at the London Group, distinguishing between the physical water stock, the economically recoverable component, and the asset value, and identifying the own-account abstraction gap, and the treatment of soil water and glaciers, as the two key boundary questions requiring resolution before the framework could be fully operationalised.

Table B.1. Water Resource Classifications Across SEEA Frameworks

Water Resource Type	SNA 2025 Classification	SEEA-Water 2012 Classification	SEEA CF Table 5.24 Code	SEEA EA 2021 Classification	GN D7 Accou Treatm
Surface Water (Rivers / Lakes)	AN.34 (Water resources)	EA.1312 (Lakes) / EA.1313 (Rivers)	1.2 (Lakes) / 1.3 (Rivers and streams)	Inland water ecosystems (Rivers, Lakes)	Fully in SEEA (moneta resourc (§5.11. 5.488–
Artificial Reservoirs	AN.34 (Water resources / produced assets if managed)	EA.1311 (Artificial reservoirs)	1.1 (Artificial reservoirs)	Inland water ecosystems / Modified assets	Fully in SEEA (moneta resourc (§5.11. 5.488– scope p TC dire
Unconfined Groundwater	AN.34 (Water resources)	EA.132 (Groundwater)	2 (Groundwater)	Subterranean ecosystems	Fully in SEEA (moneta resourc (§5.11. 5.488–
Fossil Confined Groundwater	AN.34 (Water resources)	EA.132 (Groundwater)	2 (Groundwater)	Subterranean ecosystems	Fully in SEEA (moneta resourc (§5.11. 5.488– fossil-a finite-h depleti treatme Annex (§3.6.1
Soil Water	*Not separately classified*	EA.133 (Soil water)	3 (Soil water)	*Absent*	Exclude SEEA (moneta resourc pending directio (§5.11. 5.488– silent)

Water Resource Type	SNA 2025 Classification	SEEA-Water 2012 Classification	SEEA CF Table 5.24 Code	SEEA EA 2021 Classification	GN D7 Accou Treatm
Glaciers & Snowpack	*Not classified as asset stock*	EA.1314 (Glaciers, snow & ice)	1.4 (Glaciers, snow & ice)	*Absent*	No SEI moneta resourc guidanc (§5.11. 5.488– silent)
Desalinated Water	Product (CPC 1800)	Product (CPC 1800)	N/A (produced asset)	*Absent (Treated as economic product)*	*No nat mecha (Treate produc change*

Note on classification codes: The SEEA-Water 2012 Classification column uses Environmental Asset (EA) codes defined in SEEA-Water (§VI.C.2, para. 6.12), which classify water resources within the SEEA-Water asset hierarchy: EA.13 = water resources; EA.131 = surface water (EA.1311 artificial reservoirs, EA.1312 lakes, EA.1313 rivers, EA.1314 glaciers, snow and ice); EA.132 = groundwater; EA.133 = soil water. They are distinct from the SEEA CF Table 5.24 codes in the adjacent column, which are SEEA CF's own water resource classification (§5.11.2): 1 = surface water (1.1 artificial reservoirs, 1.2 lakes, 1.3 rivers and streams, 1.4 glaciers, snow and ice), 2 = groundwater, 3 = soil water. Both code sets refer to the same physical resources. Note also that "EA" in these Environmental Asset codes is unrelated to the abbreviation "EA" used for the SEEA Ecosystem Accounts framework (column 4).

Annex C: Country Case Studies in Water Resource Monetary Accounting

256. This Annex summarises national and subnational implementations of water resource monetary accounts directly relevant to the method choices addressed in this Guidance Note.

Netherlands

257. The Netherlands has the most developed SEEA-scoped water resource accounts. Edens and Graveland (2014) compiled experimental monetary water resource accounts applying cost-based and opportunity cost methods, reporting unit values for surface water using a seawater desalination replacement cost benchmark of approximately €0.52/m³ (2010 prices). The Netherlands case demonstrates the Option B method in a data-rich environment and provides the clearest existing evidence on how to operationalize cost-based price substitution for official accounts.

Australia: National and Murray-Darling Basin

258. Vardon, Keith and Lindenmayer (2019) applied the SEEA framework to Australian water accounts at a sub-national scale (Central Highlands of Victoria), providing both physical and monetary accounts with river-basin-level disaggregation. Chen et al. (2025) extend this work with a more recent Australian case study valuing and accounting for water-related ecosystem services to support water pricing and management decisions. The Murray-Darling Basin water market is the most developed functioning water market globally, with seasonal allocation prices that have ranged from near zero in wet years to above AUD 1,000/ML during severe droughts (Rafey, 2023). The market demonstrates that resource rent for water is real, observable, and highly variable, consistent with the need for river-basin-level rather than national-average price estimation. The National Water Account applies the river basin-first architecture recommended in §3.2.2 (Bureau of Meteorology, 2024a, 2024b).

United States: High Plains Aquifer (Fenichel et al., 2016)

259. Fenichel et al. (2016) estimated the asset value of the High Plains (Ogallala) Aquifer in Kansas using a capital-theoretic framework, computing the shadow price $p^* = \partial V/\partial S$ directly from a dynamic programming model calibrated to observed groundwater extraction and agricultural production data. This subnational case is directly relevant to the Annex D mathematical framework and to the question of when p^* estimation is feasible as an alternative to the Harberger approximation $\bar{p}$. The study shows that p^* and $\bar{p}$ diverge substantially as the aquifer approaches depletion, the primary condition under which the resulting depletion-charge overstatement (D_{gap}, §3.6.3) becomes economically significant.

Other Country Implementations

260. Mexico (INEGI, 2021), Italy (Capriolo et al., 2020), Greece (Bekri et al., 2024), China (Ji et al., 2023), the United Kingdom (Ferrini et al., 2025), Spain (Kahil et al., 2016), and Canada (Aziz et al., 2025) provide additional documented approaches across a range of country contexts and water resource types. The Czech Republic (Horváthová, 2022)

provides a documented approach for freshwater accounts measuring the additional purification value of groundwater relative to surface water, not the total value of all water purification services.

261. Methodologically, Horváthová is closest to Option B (replacement cost): it captures the incremental cost saved by using groundwater instead of surface water requiring additional treatment, rather than the in-situ shadow price of the groundwater stock itself. It cannot therefore serve directly as an estimate of p*, but it provides a useful lower-bound benchmark where no other price data are available.

Summary Observations

262. Across all official national statistical compilations reviewed, none has published a water resource balance sheet entry derived from a formal NPV projection of future resource rents. Research implementations have demonstrated the approach, but structural challenges (particularly the absence of agreement on the discount rate and the projection of future rents) have prevented adoption in official accounts. The interim approach in Annex A is designed to allow countries to produce provisional balance sheet entries while those structural questions are resolved through the TC process.

Annex D: Mathematical Framework for Valuation Targets

263. This Annex presents the complete formal notation and the fundamental equations of the water resource valuation chain introduced in §3.2.3 and developed through §§3.4 and 3.5. The equations are applied in the worked examples in Annex E and the interim approach in Annex A. All variables are defined in §D.1 and the equations in §D.2.

D.1 Variable Definitions

Symbol	Meaning	Observed or Derived
r	Discount rate	Observed: national accounts practice (§3.5.2)
S	Physical stock (opening)	Observed: physical asset account
g_t	Natural recharge (net of natural losses)	Observed: hydrological data
q_t	Abstraction/extraction	Observed: metered or estimated withdrawal
$q_{t,net}$	Abstraction net of returns	Derived: q_t minus mandated/voluntary returns (§3.2.3)
R_t	Resource rent per unit	Observed (Tier 1) or Derived (Tier 2, via Options B–F)
F_t	Annual flow value (= $R_t \times q_t$)	Derived: computed from R_t and q_t
V	Stock asset value	Derived: NPV of projected F_t stream (eq. D.2)
p^*	Marginal shadow price (= $\partial V/\partial S$)	Derived: theoretical, rarely estimated directly
$\bar{p}$	Harberger approximation ($\frac{1}{2}(V/S_0+V/S_1)$, $\approx V/S_0$ if $\Delta S/S$ small)	Derived: operational proxy for p^*
D_t	Depletion charge	Derived: from $\bar{p}$, $q_{t,net}$, g_t (eq. D.5)
Addition_t	Case 3 (under-extraction) stock addition, stored resources	Derived: $\bar{p} \times (g_t - q_t\text{,net})$; zero except Case 3 (§3.6.1, eq. D.6)
OCV_t	Balancing item	Derived: $F_t - (q_t \times \bar{p})$ (§D.2, para. 271)
REV_t	Revaluation (price-level change on unchanged stock)	Derived: from $\bar{p}_t$ and $\bar{p}_{t+1}$ (§3.6.3, eq. D.6)

D.2 The Valuation Equations

264. The six equations below form the complete valuation chain. Equations (D.1)–(D.6) correspond to equations introduced in the body of this Guidance Note. Equation (D.6) is the asset account reconciliation identity from §3.6.3. The observed-versus-derived status of every symbol below (S, g_t, q_t, q_t,net, R_t, F_t, V, p*, p̄, D_t, $Addition_t$, OCV_t, REV_t) is tabulated in §3.5.1; the discount rate r, used in equation (D.2), is tabulated in the table above.

(D.1) $F_t = R_t \cdot q_t$ [annual flow value, resource rent]

265. Annual flow value F_t is the value of water extracted during the accounting period as a productive input above the cost of extraction. It is entered in the monetary supply and use table as a natural input and allocated across abstracting industries.

(D.2) $V = \Sigma_t [R_t \cdot q_t / (1+r)^t]$ [stock asset value]

266. V is the present value of the expected future stream of resource rents. Under the constant-rent perpetuity assumption used in Annex A: $V \approx F_t / r$. For renewable resources the summation runs over an indefinite horizon; for fossil aquifers the horizon is bounded by T = S/q.

(D.3) $p^* = \partial V/\partial S$ [marginal unit in situ price]

267. p* is the shadow price of the resource stock, the reduction in total national wealth from extracting one additional unit rather than leaving it in the ground. When V(S) is linear in S, p* = V/S = p̄. When V(S) is concave, the empirically more realistic case as scarcity intensifies, since marginal value rises as the stock is drawn down, p̄ > p*, and the divergence grows as S falls.

(D.4) $\bar{p} = ½ (V/S_0 + V/S_1)$ [Harberger approximation, average unit price]

268. p̄ is the operationally feasible approximation of p*, used in SEEA CF monetary accounts, averaging the unit price at the opening stock S_0 and the projected closing stock S_1 ($S_1 = S_0 + g_t - q_t$,net). Where ΔS/S is small (§3.5.4), the difference between the two is small and compilers may use the simpler form $\bar{p} \approx V/S_0$, recording the simplification in metadata (§3.5.4). The approximation error is small when ΔS/S is small and the resource is far from exhaustion. It can be substantial for fossil aquifers approaching depletion.

(D.5) $D_t = \bar{p} \times \max(0, q_t\text{,net} - g_t)$ [depletion charge, asset account]

269. D_t is recorded in the production account as a cost of production under SNA 2025, reducing NDP, NNI, and net saving. Special cases: (i) fossil aquifer ($g_t = 0$): $D_t = \bar{p} \cdot q_t$,net, all extraction is depletion; (ii) extraction at or below sustainable yield (q_t,net ≤ g_t): $D_t = 0$, the floor stated in the formula above; for stored resources (groundwater, reservoirs), the surplus ($g_t - q_t$,net) is recorded separately as $Addition_t = \bar{p} \times (g_t - q_t$,net) in the asset account (eq. D.6) and as a negative depletion entry of equal magnitude, $-Addition_t$, in the production account (§3.6.1); for unstorable flowing water, neither entry is recorded (§3.6.1); (iii) g_t unavailable: D_t = NA.

(D.6) $V_t + Addition_t - D_t + REV_t + OCV_t = V_{t+1}$ [asset account identity]

270. This reconciliation identity links the opening and closing stock values through the capital account, revaluation account, and other changes in volume account. $Addition_t$ is the Case 3 (under-extraction, stored resources) stock increase valued at p̄ (§3.6.1); it is zero except in that case and is mutually exclusive with D_t within a period for a given resource type (§3.6.2).

REV_t is the revaluation from price changes during the period. $OCV_t = F_t - (q_t \times \bar{p})$ is the balancing item that absorbs the difference between the MSUT valuation of abstraction (at current-period rent) and the asset account valuation (at shadow price of the stock). The sign convention and its interpretation are stated explicitly in §3.6.3.

271. In general, V_{t+1} computed via the identity (D.6) will differ from $\bar{p} \times S_1$ when current rent F_t and stock shadow price $\bar{p} \times q_t$ diverge; the OCV term is the balancing item that reconciles the two. Compilers should treat V as chained across periods through this identity; $\bar{p} \times S$ is a derived cross-check on that chain, not an alternative method for establishing V independently in any given period. Recomputing V from S and a freshly estimated $\bar{p}$ each period reintroduces the undefined-price-at-zero-stock problem set out in §3.4.1 and §3.5.1, and can drift from the chained value without a corresponding OCV or REV entry to explain the gap.

D.3 Properties and Approximation Error

272. Equations (D.1)–(D.5) form the theoretically correct chain. The operational SEEA CF formula substitutes $\bar{p}$ from equation (D.4) for p^* in equation (D.5). The two prices coincide when V(S) is linear in S. When V(S) is concave (the empirically more realistic case, since marginal value rises as the stock is drawn down) $\bar{p} > p^*$, and the substitution overstates the true depletion cost. The magnitude of this error depends on the curvature of V(S), which is aquifer-specific, so no single $\Delta S/S$ cutoff applies generally. Compilers should treat divergence beyond the §3.5.4 threshold as the point where this error also warrants attention, growing substantially as fossil aquifers approach exhaustion (Annex E, Example 4).

273. The conversion from annual flow value F_t to stock value V via equation (D.2) requires: (a) a projection of future resource rents over the relevant horizon; (b) assumptions about extraction volumes and recharge rates over that horizon; and (c) a discount rate r. Each of these is contested for water resources. Annex A proposes the constant-rent perpetuity as an interim assumption, with explicit documentation of the resulting bias.

Annex E: Worked Examples, Water Resource Monetary Accounts

274. This annex shows the full compilation chain through seven worked examples. Example 1 is a renewable unconfined aquifer. Example 2 is a fossil confined aquifer with no recharge. Example 3 is an over-extracted surface water body. Example 4 shows unit price divergence as a fossil aquifer nears exhaustion. Example 5 shows MSUT–asset account reconciliation. Example 6 shows sustainable extraction, with depletion less than rent and a scarcity premium. Example 7 compares the AN.34 depletion treatment against the GN D4 Option 3 produced-asset treatment for a reservoir with a rising stock. All examples use the Annex D equations and the Annex A interim approach. All examples assume zero return flows, so q_t,net (§3.2.2) equals observed q_t throughout; where return flows are material, substitute q_t,net for q_t in equation D.5. All examples also report ΔS/S well under the §3.5.4 threshold, so the simplified $\bar{p} \approx V/S_0$ form of equation D.4 applies directly; compilers with larger ΔS/S should use the full two-point average.

Example 1: Renewable Unconfined Aquifer

275. Example 1 shows the calculation for a renewable, unconfined aquifer. It also shows the sensitivity to the discount rate.

Parameters: S_0 = 500 km³, q_t = 10 km³/yr, g_t = 8 km³/yr, R_t = Int$0.50/m³, r = 4%.

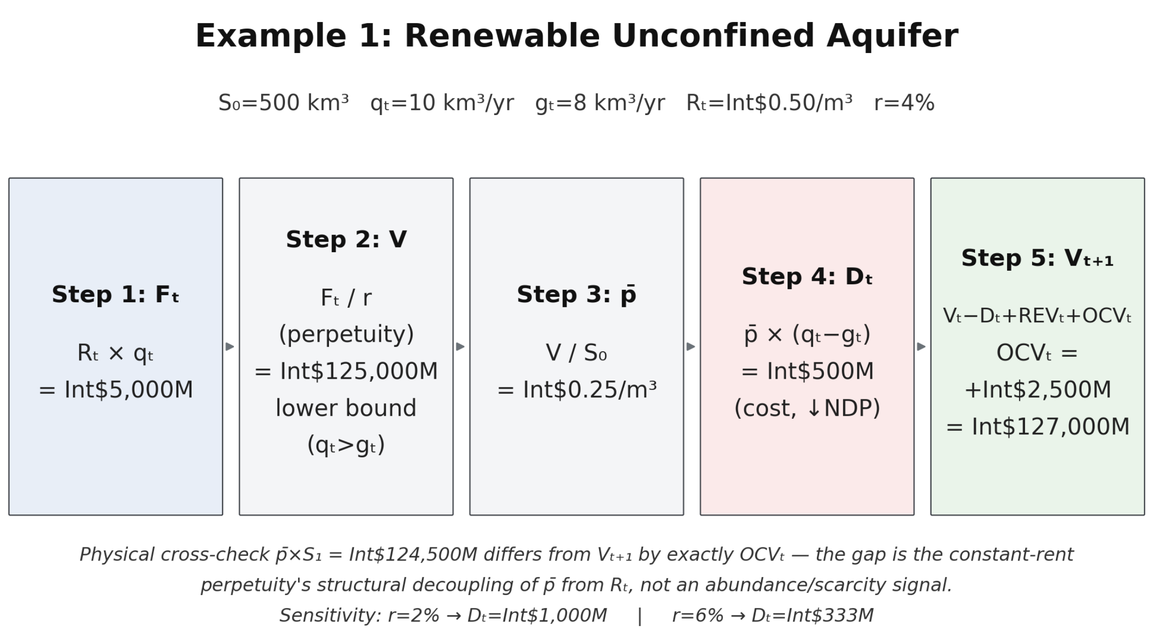

Figure E.1. Example 1: Renewable Unconfined Aquifer

Step 1: Annual flow value (eq. D.1): $F_t = R_t \times q_t$ = Int$0.50/m³ × 10 km³ = Int$5,000 million. The MSUT allocates 70% to ISIC A (agriculture) and 30% to ISIC B (industry).

Step 2: Stock asset value (eq. D.2, perpetuity): $V \approx F_t/r$ = Int$5,000/0.04 = Int$125,000 million. Because extraction exceeds recharge ($q_t > g_t$), the stock is being drawn down; if future resource rents rise as scarcity increases, this perpetuity estimate is a lower bound on true V (Annex A, Step 2). Record this bias in metadata alongside the estimate.

Step 3: Unit price (eq. D.4): $\bar{p} = V/S_0$ = Int$125,000m / 500 km³ = Int$0.25/m³. ΔS/S = 0.4%. The Harberger approximation error is small.

Step 4: Depletion charge (eq. D.5): $D_t = \bar{p} \times (q_t - g_t)$ = Int$0.25 × (10 − 8) km³ = Int$500 million. The production account records this as a cost of production. It reduces NDP.

Step 5: Balance sheet. $S_1 = S_0 + g_t - q_t$ = 498 km³. No genuine volume change occurred (no reclassification, catastrophic loss, or stock revision), but $OCV_t = F_t - (q_t \times \bar{p})$ = Int$5,000 million − (10 km³ × Int$0.25/m³) = Int$5,000 − Int$2,500 = +Int$2,500 million (§3.6.3): under the constant-rent perpetuity used in Step 2, $\bar{p}$ is derived independently of R_t, so this gap reflects the approximation method itself, not an administered-pricing signal (Annex A, Step 2). REV_t = 0 (no price change during the period). $V_{t+1} = V_t - D_t + REV_t + OCV_t$ = Int$125,000 million − Int$500 million + Int$2,500 million = Int$127,000 million. This exceeds the physical cross-check $\bar{p} \times S_1$ = Int$124,500 million by exactly OCV_t, consistent with the identity-based V being the authoritative chained value (Annex D, para. 272); Example 5 examines this reconciliation gap in detail.

Sensitivity to discount rate. At r = 2%, D_t = Int$1,000 million. At r = 6%, D_t = Int$333 million. Compilers must record the assumed r. Compilers must report this sensitivity range in metadata.

Example 2: Fossil Confined Aquifer ($g_t = 0$)

276. Example 2 shows depletion of wealth from extraction in a fossil confined aquifer.

Parameters: S_0 = 100 km³, q_t = 5 km³/yr, g_t = 0, R_t = Int$0.80/m³, r = 4%.

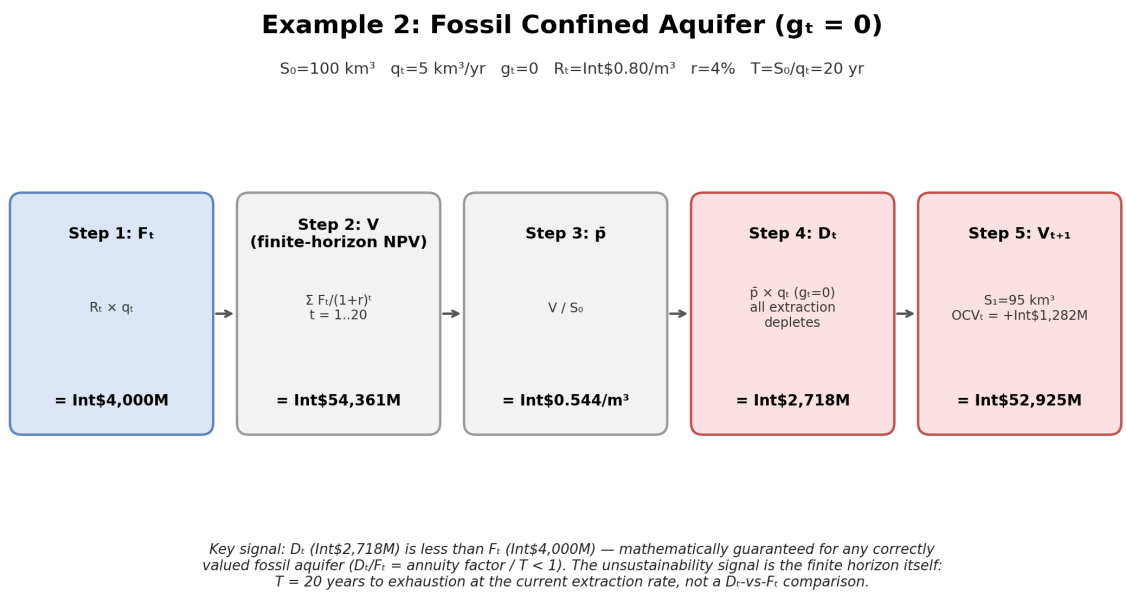

Figure E.2. Example 2: Fossil Confined Aquifer (g_t = 0)

Step 1: F_t = Int$0.80 × 5 km³ = Int$4,000 million.

Step 2: The constant-rent perpetuity shortcut used in Annex A's interim approach applies only where a resource has an indefinite horizon. This aquifer is fossil (g_t = 0), so it does not: its remaining life is T = S_0/q_t = 100/5 = 20 years. Applying the perpetuity formula anyway, V ≈ Int$4,000/0.04 = Int$100,000 million, prices 20 years of rent as if it continued forever. The theoretically correct value is the finite-horizon net present value required by eq. D.2 and Annex A's own rule for fossil aquifers: discounting Int$4,000 million at r = 4% for t = 1 through 20 gives V = Int$54,361 million, 46% below the perpetuity figure (the perpetuity number overstates V by a factor of 1.84). Example 2 uses V = Int$54,361 million from Step 3 onward; the perpetuity figure above illustrates the error Annex A's fossil-aquifer rule exists to prevent.

Step 3: $\bar{p}$ = Int$54,361m / 100 km³ = Int$0.544/m³. ΔS/S = 5%. Note this in metadata.

Step 4: Because g_t = 0, all extraction is depletion (eq. D.5 with g_t = 0): $D_t = \bar{p} \times q_t$ = Int$0.544 × 5 km³ = Int$2,718 million.

Step 5: S_1 = 95 km³ (unchanged by the valuation correction; S_1 depends only on physical extraction). $OCV_t = F_t - (q_t \times \bar{p})$ = Int$4,000 million − (5 km³ × Int$0.544/m³) = Int$4,000 − Int$2,718 = Int$1,282 million (§3.6.3): OCV_t is now positive, because current rent F_t exceeds the finite-horizon depletion charge D_t, the reverse of Example 1's perpetuity-decoupling gap (Annex A, Step 2), where the perpetuity-based D_t exceeded F_t. REV_t = 0 (no price change). $V_{t+1} = V_t - D_t + REV_t + OCV_t$ = Int$54,361 million − Int$2,718 million + Int$0 + Int$1,282 million = Int$52,925 million. ΔV = −Int$1,436 million: smaller than D_t alone, because the positive OCV_t partly offsets it, consistent with a fossil aquifer being drawn down toward its 20-year horizon rather than losing wealth faster than D_t implies.

Key signal: Under correct finite-horizon valuation, D_t (Int$2,718 million) is less than F_t (Int$4,000 million) — and this is not incidental. For any fossil aquifer valued over its true finite life $T = S_0/q_t$ at discount rate $r > 0$, D_t/F_t reduces to the T-year annuity factor divided by T, which is always below 1, because each discounted term in that factor is itself below 1. $D_t < F_t$ therefore holds for every correctly valued fossil aquifer; it is not, by itself, evidence that extraction is sustainable. The signal that this aquifer's use is unsustainable is the finite horizon itself: at q_t = 5 km³/yr, S_0 = 100 km³ supports only T = 20 years of extraction before exhaustion. Compilers should track this through the falling stock value V and remaining physical stock S in each period's asset account (§3.6.3), not by comparing D_t to F_t within a single period.

Example 3: Over-Extracted Surface Water Body

Example 3 shows depletion in an over-extracted surface water body.

Parameters: S_0 = 50 km³, q_t = 15 km³/yr, g_t = 12 km³/yr, R_t = Int$0.30/m³, r = 4%.

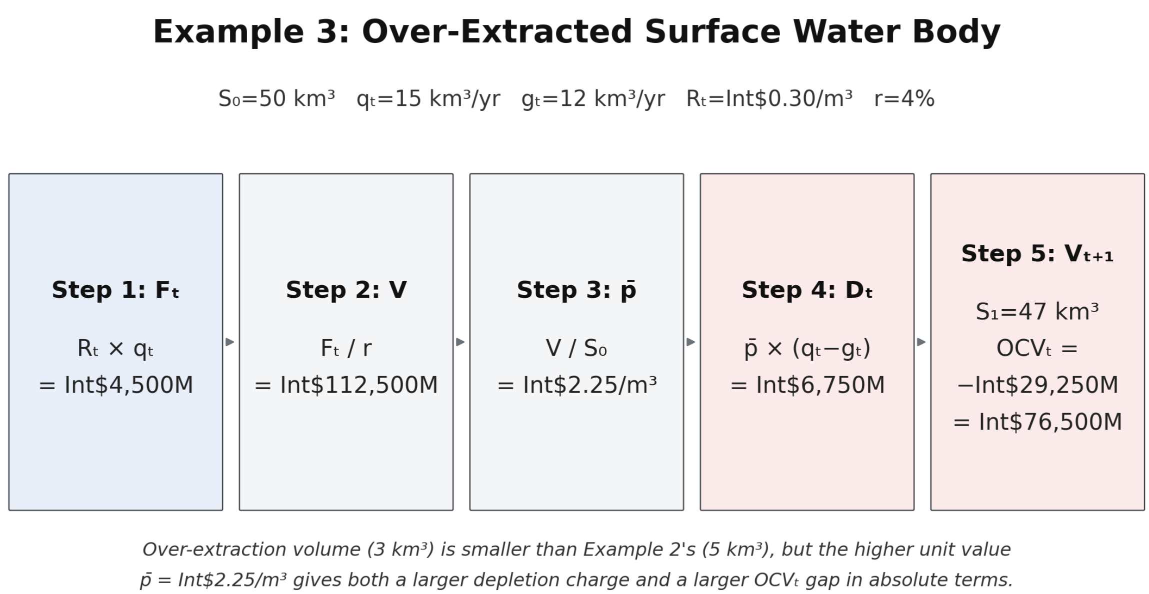

Figure E.3. Example 3: Over-Extracted Surface Water Body

Step 1: F_t = Int$0.30 × 15 km³ = Int$4,500 million.

Step 2: V ≈ Int$4,500/0.04 = Int$112,500 million.

Step 3: $\bar{p}$ = Int$112,500m / 50 km³ = Int$2.25/m³. ΔS/S = 6%. Note this in metadata.

Step 4: $D_t = \bar{p} \times (q_t - g_t)$ = Int$2.25 × (15 − 12) km³ = Int$6,750 million. The over-extraction volume is smaller than in Example 2: 3 km³ against 5 km³. But the higher unit value $\bar{p}$ gives a larger depletion charge in absolute terms.

Step 5: S_1 = 47 km³. $OCV_t = F_t - (q_t \times \bar{p})$ = Int$4,500 million − (15 km³ × Int$2.25/m³) = Int$4,500 − Int$33,750 = −Int$29,250 million (§3.6.3), the same perpetuity-decoupling gap as Example 1 (Annex A, Step 2). REV_t = 0 (no price change). $V_{t+1} = V_t - D_t + REV_t + OCV_t$ = Int$112,500 million − Int$6,750 million + Int$0 − Int$29,250 million = Int$76,500 million. ΔV = −Int$36,000 million; depletion (D_t) alone does not account for the full wealth loss.

Example 4: p* versus p̄, Unit Price Divergence Near Exhaustion

277. This example evaluates a second fossil aquifer, structurally identical to Example 2 (S_0 = 100 km³, q_t = 5 km³/yr, g_t = 0, r = 4%) but with a higher resource rent (R_t = Int$2.50/m³ rather than Int$0.80/m³), at two points in its depletion path. The higher rent is used so that p̄ can rise far enough near exhaustion to cross the Recommendation 8 substitute ceiling (§3.6.1): under correct finite-horizon valuation, p̄ is bounded above by R_t itself, so at Example 2's own rent of Int$0.80/m³, well below the Int$2.00/m³ ceiling used here, the ceiling could never bind at any point along that aquifer's depletion path. This example shows where the Harberger approximation breaks down. As S falls and p̄ = V/S rises, the slope of the chord from the origin (p̄) moves further from the slope of the tangent to the V(S) curve (p*). This divergence matters economically for any fossil aquifer beyond the first few years of depletion.

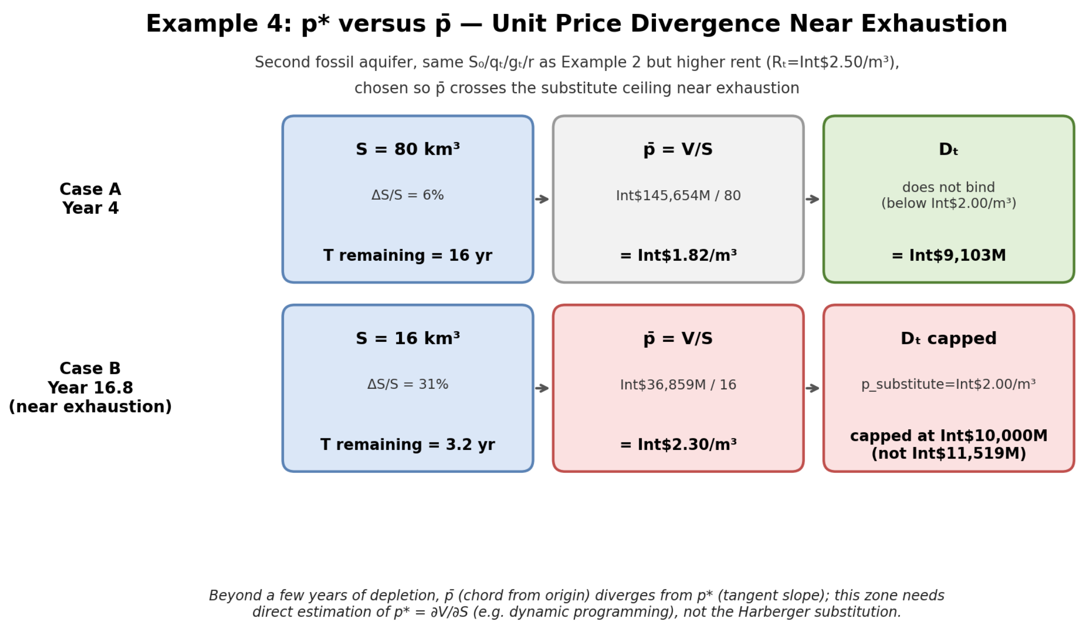

Figure E.4. Example 4: p* versus p̄, Unit Price Divergence Near Exhaustion

Case A, S = 80 km³ (year 4): remaining horizon $T = S/q_t$ = 80/5 = 16 years. V = Int$145,654 million (finite-horizon NPV at R_t = Int$2.50/m³ over 16 years). p̄ = V/S = Int$145,654 million / 80 km³ = Int$1.82/m³, below the Int$2.00/m³ substitute ceiling. ΔS/S = 6%. D_t = Int$9,103 million.

Case B, S = 16 km³ (year 16.8, near exhaustion). Remaining horizon T = S/q_t = 16/5 = 3.2 years. V = Int$36,859 million. $\bar{p}$ = V/S = Int$36,859 million / 16 km³ = Int$2.30/m³. ΔS/S = 31%. The Harberger approximation now operates far outside its valid range. Substitute ceiling: with $p_{substitute}$ = Int$2.00/m³, $\bar{p}$ now exceeds the ceiling, so D_t is capped at Int$10,000 million instead of the uncapped Int$11,519 million. In this zone, defensible accounts need direct estimation of p* = ∂V/∂S, using dynamic programming or another method.

Example 5: MSUT and Asset Account Reconciliation

278. This example decomposes the OCV_t = +Int$2,500 million already computed in Example 1, Step 5, and shows how it changes when R_t changes (Scenario B). A non-zero OCV_t signals a gap between the MSUT rent estimate and the asset-account shadow price; under the constant-rent perpetuity (Annex A, Step 2), this gap is persistently present because $\bar{p}$ is derived independently of R_t, not only when administered pricing is at work (§3.6.3). A positive OCV_t occurs when the current-period rent exceeds the capitalized stock value per unit extracted; a negative OCV_t shows the reverse. Where the magnitude is larger than the perpetuity-decoupling effect alone would produce, review the Tier 1 data or consider whether administered pricing is suppressing observed rents below scarcity value.

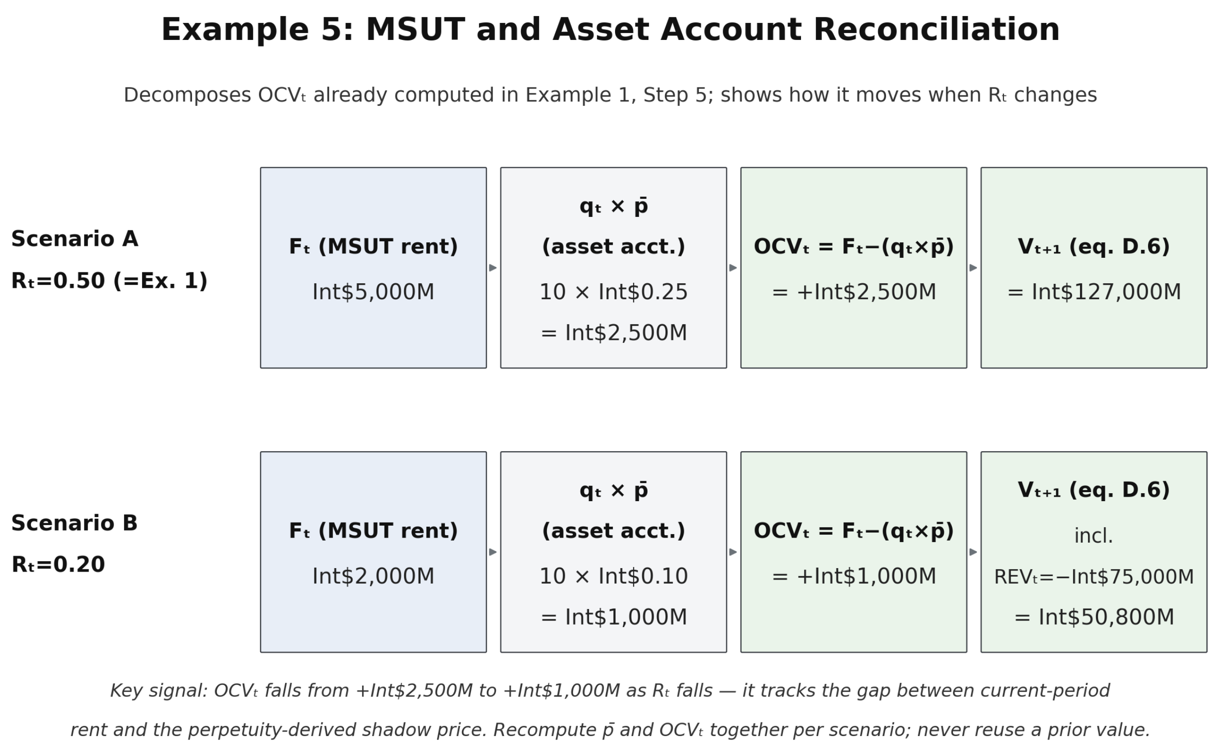

Figure E.5. Example 5: MSUT and Asset Account Reconciliation

Step 1: MSUT natural input entry. F_t = Int$5,000 million. The MSUT records this as a natural input, allocated across abstracting industries.

Step 2: Asset account extraction value. $q_t \times \bar{p}$ = 10 km³ × Int$0.25/m³ = Int$2,500 million. The MSUT value, Int$5,000 million, reflects the current-period rent. The asset account value, Int$2,500 million, reflects the capitalized shadow price of the stock. In general, these two figures are not equal.

Step 3: OCV balancing item. $OCV_t = F_t - (q_t \times \bar{p})$ = Int$5,000 − Int$2,500 = +Int$2,500 million, matching Example 1, Step 5. Under the constant-rent perpetuity (Annex A, Step 2), this gap arises because $\bar{p}$ is derived independently of R_t; it does not, on its own, indicate genuine abundance or scarcity. Record it in metadata alongside a note on the valuation method used.

Step 4: Reconciliation identity (eq. D.6). $V_{t+1} = V_t - D_t + REV_t + OCV_t$ = Int$125,000 million − Int$500 million + Int$0 + Int$2,500 million = Int$127,000 million, matching Example 1, Step 5. The physical cross-check $\bar{p} \times S_1$ = Int$0.25 × 498 km³ = Int$124,500 million differs from this by exactly OCV_t; per Annex D (para. 272), the identity-based V is the authoritative chained value, and this gap is expected whenever $OCV_t \neq 0$. Scenario B below shows the same reconciliation with a different R_t.

Scenario B. Lower rent, fully cascaded. If R_t falls to Int$0.20/m³, recalculate all downstream quantities before deriving the OCV.

Step 1: $F_t = R_t \times q_t$ = Int$0.20 × 10 km³ × 10⁹ m³/km³ / 10⁶ = Int$2,000 million.

Step 2: $V = F_t / r$ = Int$2,000 / 0.04 = Int$50,000 million.

Step 3: $\bar{p} = V / S_0$ = Int$50,000 × 10⁶ / (500 × 10⁹) = Int$0.10/m³.

Step 4: $D_t = (q_t - g_t) \times \bar{p}$ = 2 km³ × 10⁹ × Int$0.10 / 10⁶ = Int$200 million.

Step 5: Balance sheet (eq. D.6). S_1 = 498 km³ (same physical path as Scenario A; only R_t has changed). The price drop revalues the opening stock: $REV_t = (\bar{p} \times S_0) - V_t$ = (Int$0.10/m³ × 500 km³) − Int$125,000 million = −Int$75,000 million. $OCV_t = F_t - (q_t \times \bar{p})$ = Int$2,000 − Int$1,000 = +Int$1,000 million, the same formula as Scenario A applied at the new $\bar{p}$. $V_{t+1} = V_t - D_t + REV_t + OCV_t$ = Int$125,000 million − Int$200 million − Int$75,000 million + Int$1,000 million = Int$50,800 million. The physical cross-check $\bar{p} \times S_1$ = Int$0.10 × 498 km³ = Int$49,800 million differs by exactly OCV_t, as expected (Annex D, para. 272; Scenario A above).

Key signal: OCV_t falls from +Int$2,500 million (Scenario A) to +Int$1,000 million (Scenario B) because a lower R_t reduces F_t while $q_t \times \bar{p}$ falls too, but not by the same proportion; the two scenarios show that OCV_t tracks the gap between the current-period rent and the perpetuity-derived shadow price, not a fixed administered-pricing signal. A materially larger or smaller OCV_t than the perpetuity-decoupling effect alone would produce is the signal worth investigating (§3.6.3). NOTE: if a companion spreadsheet or tool computes OCV_t for this scenario, verify it recalculates $\bar{p}$ and OCV_t together for the new R_t; reusing Scenario A's OCV_t (+Int$2,500 million) here would be incorrect, and so would assuming $OCV_t = 0$. The correct value is +Int$1,000 million.

Example 6: Depletion Less Than Rent, Sustainable Extraction with Scarcity Premium

Parameters: S_0 = 500 km³, q_t = 8 km³/yr, g_t = 10 km³/yr, R_t = Int$0.40/m³, r = 4%. NOTE: Extraction is below natural recharge ($q_t < g_t$). This resource is in sustainable use.

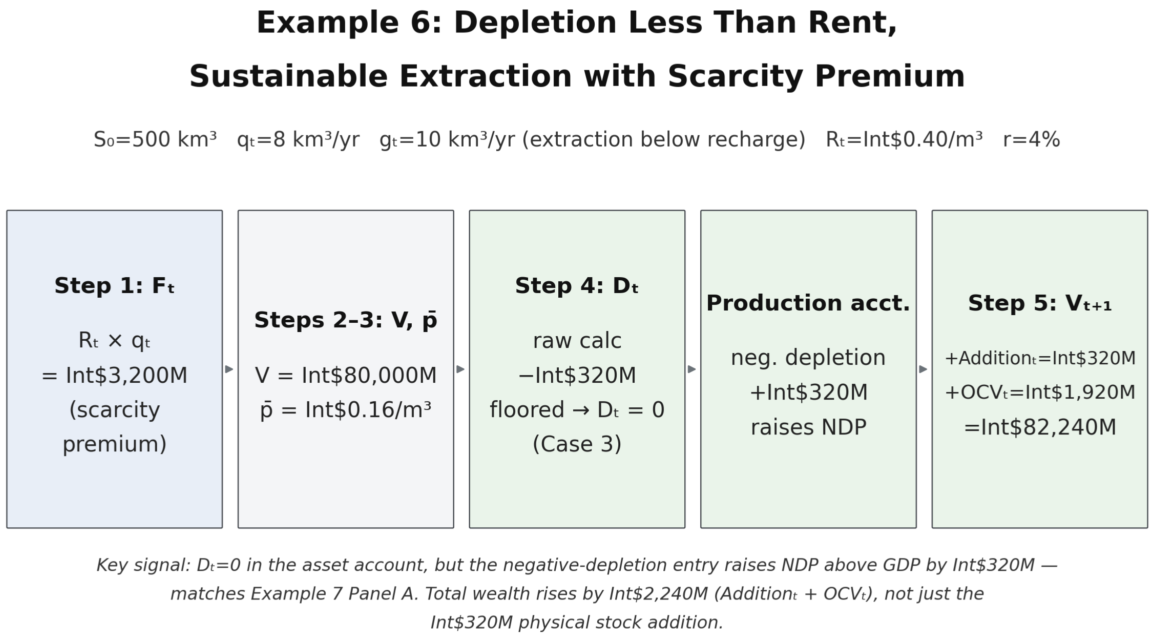

Figure E.6. Example 6: Depletion Less Than Rent, Sustainable Extraction with Scarcity Premium

Step 1: Annual rent: $F_t = R_t \times q_t$ = Int$0.40/m³ × 8 km³ × 10⁹ m³/km³ / 10⁶ = Int$3,200 million. R_t is defined as the net return to the water stock above the full cost of extraction (§3.4); the entire unit rent R_t = Int$0.40/m³ is therefore scarcity premium, not a return to any produced input. Even though extraction stays within the sustainable yield ($q_t < g_t$) and the stock is not being drawn down, water access still carries positive economic value: the scarcity premium captured in the current period is F_t = Int$3,200 million.

Step 2: Asset value: $V = F_t / r$ = Int$3,200 / 0.04 = Int$80,000 million.

Step 3: Unit shadow price: $\bar{p} = V / S_0$ = Int$80,000 × 10⁶ / (500 × 10⁹) = Int$0.16/m³.

Step 4: Depletion. $D_t = (q_t - g_t) \times \bar{p}$ = (8 − 10) km³ × 10⁹ × Int$0.16 / 10⁶ = −Int$320 million, so D_t = 0 in the asset account (Case 3, §3.6.1). Because this is a stored resource, the same amount also enters the production account as a negative depletion charge, raising NDP and net saving by Int$320 million (§3.6.1, para. 143).

Step 5: Balance sheet (eq. D.6). S_t = 500 + 10 − 8 = 502 km³. D_t = 0 under the sustainable-use rule, and no price change, so REV_t = 0. The net physical addition to the stock ($g_t > q_t$) enters as $Addition_t$ = Int$320 million (§3.6.1), a separate line item, not OCV_t. $OCV_t = F_t - (q_t \times \bar{p})$ = Int$3,200 million − (8 km³ × Int$0.16/m³) = Int$3,200 − Int$1,280 = +Int$1,920 million (§3.6.3): as in Example 1, this reflects the gap the constant-rent perpetuity shortcut introduces between F_t and $q_t \times \bar{p}$ (Annex A, Step 2), not an administered-pricing signal. $V_{t+1} = V_t - D_t + REV_t + Addition_t + OCV_t$ = Int$80,000 million + Int$320 million + Int$1,920 million = Int$82,240 million. This exceeds the physical cross-check $\bar{p} \times S_t$ = Int$80,320 million by exactly OCV_t, consistent with the identity-based V being the authoritative chained value (Annex D, para. 272).

Key signals: $D_t = 0$ in the asset account, but because this is a stored resource, a negative depletion entry of Int$320 million enters the production account (§3.6.1), raising NDP above GDP by that amount, matching Example 7 Panel A's treatment of the identical scenario under standard AN.34 classification. The resource generates real current income: resource rent (scarcity premium) F_t = Int$3,200 million, computed in Step 1. This is because extraction stays within sustainable yield. The stock increases, which the account records as an addition to the stock; the balance sheet separately carries a +Int$1,920 million OCV_t entry from the same perpetuity-shortcut gap Example 1 shows (§3.6.3), so total wealth rises by Int$2,240 million, not just the Int$320 million physical addition. This contrasts with Examples 2 and 3, where $D_t > F_t$. Depletion greater than rent is the defining signal of economically unsustainable extraction.

Example 7: D4 Option 3 versus Standard AN.34 Treatment, Reservoir Stock Increase

Parameters: S_0 = 500 km³, q_t = 8 km³/yr, g_t = 10 km³/yr, R_t = Int$0.40/m³, r = 4%. Same physical scenario as Example 6 (a stored resource (reservoir) with extraction below inflow) compared here under two different asset classifications.

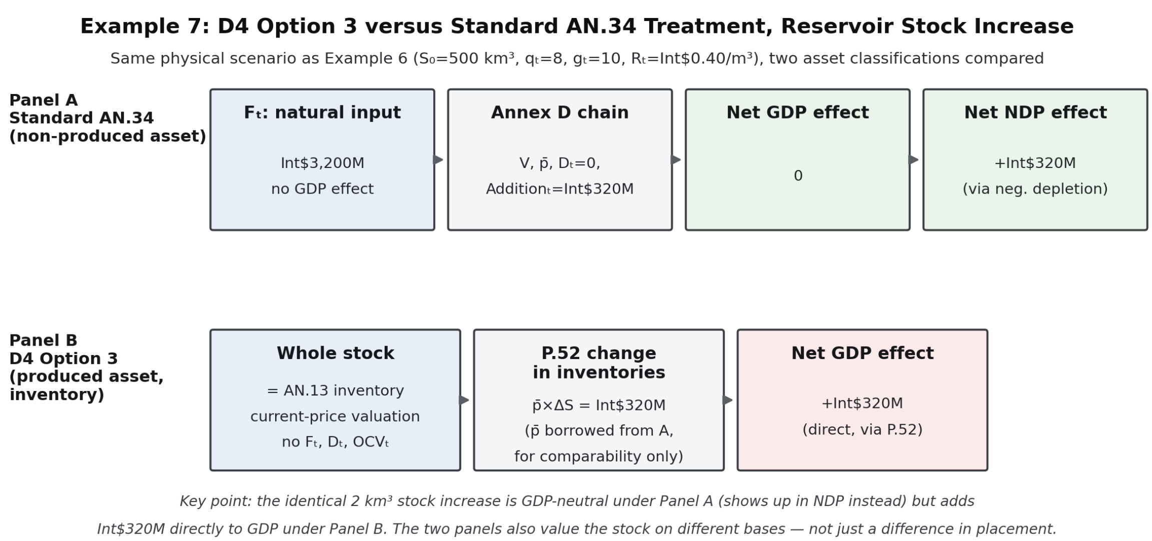

Figure E.7. Example 7: D4 Option 3 versus Standard AN.34 Treatment, Reservoir Stock Increase

Panel A: standard AN.34 treatment (non-produced asset, §3.6.1 Case 3). Step 1: $F_t = R_t \times q_t$ = Int$0.40 × 8 km³ = Int$3,200 million, recorded as a natural input in the production account; this does not add to GDP. Step 2: $V = F_t/r$ = Int$80,000 million. Step 3: $\bar{p} = V/S_0$ = Int$0.16/m³. Step 4: $D_t = (q_t - g_t) \times \bar{p}$ = −Int$320 million, so $D_t = 0$ (Case 3). Step 5: because a reservoir is a stored resource, record both the addition to the asset account ($\bar{p} \times (g_t - q_t)$ = Int$320 million) and the negative depletion entry in the production account (Int$320 million, raising NDP and net saving). The balance sheet also carries $OCV_t = F_t$

− (q_t × p̄) = Int$3,200 − Int$1,280 = +Int$1,920 million (§3.6.3; Example 6, Step 5), so V_{t+1} = Int$80,000 + Int$320 + Int$1,920 million = Int$82,240 million. Net GDP effect: zero. Net NDP effect: +Int$320 million.

Panel B: GN D4 Option 3 treatment (produced asset, inventory). Under D4 Option 3 the reservoir, and its whole stored volume, is recorded as a produced asset (inventory), not as a non-produced natural resource under AN.34; the two treatments are alternatives, not additive (§3.8.1). This changes how the stock, not only the period's flow, is treated: Panel A's Annex D apparatus (F_t, V = F_t/r, p̄, D_t, OCV_t) capitalizes resource rent to value a non-produced asset and has no counterpart under Option 3. Instead, standard SNA inventory accounting applies to the whole stock: opening and closing balances are valued at current prices (ordinarily replacement cost, via a perpetual-inventory-type method), period-to-period changes run through changes in inventories (P.52), a gross-capital-formation entry on the expenditure side of GDP, and price effects run through ordinary inventory holding gains and losses, not through a depletion charge or an OCV reconciliation term. There is accordingly no F_t, D_t, or OCV_t line for this reservoir under Option 3; if the reservoir also supports a priced use, that sale is a real transaction and enters GDP as ordinary output under either panel, independent of which asset classification the stored water itself carries. Using the same physical change and Panel A's p̄ for comparability: ΔS = g_t − q_t = 2 km³; P.52 = p̄ × ΔS = Int$0.16 × 2 km³ = Int$320 million, entering GDP directly. GN D4 does not specify the SNA inventory valuation method for reservoir water; p̄ is borrowed from Panel A's Annex D chain solely to make the two panels comparable here, not because Option 3 requires it. Net GDP effect: +Int$320 million.

Key point: the same 2 km³ stock increase is GDP-neutral under the AN.34 depletion framework (Panel A) but adds Int$320 million to GDP under the D4 Option 3 inventory framework (Panel B), because the two frameworks present the change through different channels: a negative depletion credit to NDP under Panel A, versus inventory investment recorded directly in GDP under Panel B. This is not only a difference in where the value appears in the accounts: the two panels also value the stock on different bases, capitalized resource rent (Annex D) under Panel A versus current-price inventory valuation under Panel B, and Panel B carries no F_t, D_t, or OCV_t line at all. Per §3.8.1, adopting D4 Option 3 for a given reservoir does not change the resource-rent valuation methods this note recommends for water still accounted under AN.34 elsewhere; it does mean that reservoir's stock is no longer valued or reported under AN.34 or the Annex D chain at all, only as produced-asset inventory, since the two treatments are alternatives, not additive.

Caveat: this comparison borrows Panel A's p̄ = Int$0.16/m³ for the P.52 entry so the two panels are numerically comparable, and assumes natural reservoir inflow is booked as ordinary P.52 inventory investment under D4 Option 3, the standard SNA mechanic for produced inventories. GN D4 does not specify either the recording mechanic or the inventory valuation method explicitly; if the TC intends a different treatment, or a different valuation basis than the illustrative p̄ used here, the GDP-line and balance-sheet magnitudes in Panel B would both change accordingly.

Annex F: From SEEA CF Water Accounts to the SNA Sequence of Accounts

F.1 Purpose and Scope

279. Annex B maps SEEA CF, SEEA Water, SEEA EA, and SNA 2025 classifications against each other, and §3.7 states the NDP formula and confirms depletion sits below the GDP line. Neither shows a compiler which SNA account, sector, and line a completed SEEA CF water asset account actually populates. This annex is that missing step. It does not repeat the classification concordance in Annex B or the conceptual NDP argument in §3.7.1–3.7.2; it assumes both and shows the compilation mechanics that follow from them.

F.2 Institutional Sector Attribution

280. This note has not previously stated who bears the depletion charge when the legal owner of a water resource and the unit extracting it are different institutional sectors, a government water authority (S.13) licensing abstraction to private agricultural or industrial producers (S.11), for example. The 2025 SNA resolves this for mineral and energy resources through the split-asset approach: resource rent is appropriated jointly by the legal owner, who receives it as property income, and the extractor, who retains the residual value of the resource rent as part of its own asset base (2025 SNA, §27.59–27.62, per OECD, 2025). Transfers of resource value from the legal owner to the extractor are recorded as other changes in the volume of assets, not capital transfers, and double-counting must be avoided by not allocating both the transferable right's value and the split-asset residual to the extractor's balance sheet.

281. This note adopts the same approach for water, which SNA 2025 and the OECD (2025) compilation guide leave unaddressed for water specifically. Depletion is not split on an all-or-nothing basis between owner and extractor. It follows SNA 2025's own worked example (§27.61–27.62): the full depletion charge D_t is recorded first as a cost of production in the extractor's production account, then reallocated in the capital account in proportion to the legal owner's share of resource rent actually received. Where the owner receives, for example, 20 percent of the resource rent as a licence fee or royalty, 20 percent of D_t is reallocated to the owner's accounts and the remaining 80 percent stays with the extractor. Where no rent is paid, the owner's share is zero and the full depletion charge and the full stock value remain with the extractor by default. That is not a separate rule; it is the zero-percent case of the same proportional split, and should be flagged in metadata since it likely understates the legal owner's wealth.

F.3 The Sequence of Accounts

282. Production account and generation of income account. The depletion charge D_t is recorded in the production account of the extracting unit's institutional sector, following the treatment stated in §3.7.1: it does not affect gross value added or GDP, only net. In the generation of income account, D_t converts the extracting sector's gross operating surplus to net operating surplus in the same way consumption of fixed capital does for produced assets. The two are reported as separate lines; a country reporting a single combined depreciation-and-depletion figure does not meet this note's disclosure standard, consistent with the metadata discipline required throughout §3.6.3.

283. Allocation of primary income account. Where the legal owner actually receives a payment for the use right, an abstraction licence fee or a water royalty, that payment is recorded as property income (rent, SNA 2025 category D.45) flowing from the extractor's sector to the owner's sector. D_t itself is not a new inter-sectoral flow: it is the accounting recognition, within the extractor's own accounts, that the resource used has a finite capacity that is being drawn down. Compilers should not double-count by treating the depletion charge as both a cost reducing the extractor's net operating surplus and as an implicit rent payment to the owner; only an observed transaction is recorded as property income. The ratio of that payment to total resource rent is the same ratio used to reallocate the depletion charge between owner and extractor in the capital account (SNA 2025, §27.61).

284. Capital account. The full depletion charge D_t initially reduces the extractor's net operating surplus in the generation of income account, but SNA 2025's split-asset approach reallocates it before it reaches net lending: the extractor's capital account carries forward only its residual share of D_t, in proportion to the share of resource rent it retains, while the legal owner's capital account is separately debited its own share, in proportion to the rent share it received as property income in the allocation of primary income account (SNA 2025, §27.61). The two shares sum to the full D_t; neither sector's net lending position can be read off D_t alone without knowing the rent-sharing ratio. At the whole-economy level, the water contribution to adjusted net saving (§3.7.2) is the sum of both sectors' shares, and a compiler working only from the whole-economy figure cannot recover which sector's saving actually declined.

285. Balance sheet, revaluation account, and other changes in volume of assets account. Following the same split-asset approach, the closing stock value V is not recorded entirely on the legal owner's balance sheet. It is split between owner and extractor in proportion to the resource-rent-sharing ratio established in the allocation of primary income account. Where that ratio is newly established or renegotiated, the split is implemented as a one-time other-changes-in-volume entry, a negative entry on the owner's balance sheet reflecting the share of future resource rent foregone to the extractor, and a corresponding positive entry on the extractor's (SNA 2025, §27.62). Where the ratio is already in place from prior periods, as in GN D7's ongoing annual compilation cycle, no fresh reallocation entry is needed each year; each sector's balance sheet simply falls by its share of that period's depletion charge, worked through in Example F.1, Step 5. Revaluation, OCV, and D_{gap} (the depletion-charge approximation error), all defined in §3.6.3, should likewise each be split and disclosed against each sector's share of the balance sheet entry, not reported only against the owner.

F.4 Reconciling GN D7's OCV with the SNA Other Changes in Volume of Assets Account

286. The physical-account OCV row in Table 3.1 and the monetary asset-account OCV term in §3.6.3 are already distinguished from each other in this note; neither should be conflated with the SNA's own other changes in volume of assets account (K.2), which is broader in scope, covering reclassifications, catastrophic losses, and uncompensated seizures across all asset types. GN D7's OCV term (§3.6.3) is one component that feeds into the water resource's entry in K.2; it is not a synonym for K.2 itself, and it does not include the depletion-charge approximation error (D_{gap}, §3.6.3), which is a separate memo item, not a component of OCV. Compilers should report GN D7's OCV as a labelled sub-component of the water resource line in K.2, not net it against other K.2 entries for other assets, and should disclose D_{gap} separately alongside it, so neither signal is lost in aggregation.

F.5 The AN.34/AN.32 Double-Counting Risk as a Sequence-of-Accounts Problem

287. §3.8.3 identifies the risk that a hydroelectric site's value is counted under both AN.34 (water resource, depletion-based) and AN.32 (energy generation capacity, other-changes-in-volume-based). In sequence-of-accounts terms, this risk is concrete: the same site's balance sheet entry could appear twice, once under each asset class, while only one of the two production accounts, whichever the compiler treats as bearing the resource, records a depletion charge reducing NDP. Compilers must select a single institutional sector's production account to carry the AN.34 depletion charge for a given hydroelectric site, document that choice, and ensure the AN.32 entry for the same site's energy generation capacity is not treated as an independent depletion event on top of it.

F.6 Worked Example: Sector-Attributed Sequence of Accounts (Example F.1, extends Annex E Example 1)

288. This example extends Annex E Example 1 (renewable unconfined aquifer: S_0 = 500 km³, q_t = 10 km³/yr, g_t = 8 km³/yr, R_t = Int$0.50/m³, r = 4%, D_t = Int$500 million) through the sequence of accounts. The water right is held by a government water authority (S.13); abstraction is carried out by private producers (S.11). The MSUT allocation of 70% to agriculture and 30% to industry (Annex E, Step 1) is treated here as entirely within S.11.

Step 1: Production account (S.11, extracting sector). Value added from water-using production includes payment for the water input. D_t = Int$500 million enters as a cost of production, per §3.7.1, only in the movement from GDP to NDP; S.11's gross value added is unaffected.

Step 2: Generation of income account (S.11). Gross operating surplus is unaffected by D_t. Net operating surplus is reduced by Int$500 million, reported as a line separate from consumption of fixed capital on produced assets.

Step 3: Allocation of primary income account. Assume the water authority (S.13) charges an abstraction licence fee equal to 20 percent of the resource rent, Int$1,000 million of F_t = Int$5,000 million (Annex E, Step 1), an observed market transaction under Option A (§3.4.2), recorded as property income (D.45, rent) from S.11 to S.13. This 20 percent is the ratio used in Steps 4 and 5 to reallocate the depletion charge and the stock value between the two sectors (SNA 2025, §27.61–27.62).

Step 4: Capital account. The full D_t = Int$500 million initially reduces S.11's net operating surplus (Step 2). Following SNA 2025's split-asset approach (§27.61), it is then reallocated in proportion to the rent-sharing ratio in Step 3: S.13's share is 20 percent of D_t = Int$100 million, debited to S.13's capital account; S.11's residual share is 80 percent of D_t = Int$400 million, the amount that actually reduces S.11's net lending position. At the whole-economy level, the Int$500 million reduction in adjusted net saving (§3.7.2) is the sum of both sectors' shares, Int$100 million from S.13 and Int$400 million from S.11, not a single-sector effect.

Step 5: Balance sheet, split between S.11 and S.13. SNA 2025's own example (§27.62) illustrates a one-time other-changes-in-volume entry recognising a newly established rent-sharing arrangement; GN D7's compilation cycle instead encounters an arrangement already in place, so the relevant effect each period is simpler. If the 20/80 split established in Step 3 already applies to the opening stock (S.13: Int$25,000 million of V_t = Int$125,000 million; S.11: Int$100,000 million), then the current period's depletion and OCV both split the same way (§3.6.3, §F.3): depletion reduces S.13's balance sheet by its Int$100 million share (Step 4) and S.11's by its Int$400 million share; OCV_t = +Int$2,500 million (Annex E, Example 1, Step 5) adds Int$500 million to S.13's balance sheet and Int$2,000 million to S.11's, at the same 20/80 ratio. Net: S.13's balance sheet moves from Int$25,000 million to Int$25,400 million; S.11's moves from Int$100,000 million to Int$101,600 million. The two closing balances sum to V_{t+1} = Int$127,000 million (Annex E, Example 1, Step 5). A newly granted or renegotiated use right, by contrast, would require the one-time OCV entry SNA 2025 illustrates, sized to the value of resource rent being reassigned, not to that period's depletion or reconciliation gap alone. Compilers must document which case applies. A country reporting only a consolidated total-economy balance sheet does not need to resolve any of this; a country compiling institutional sector accounts does.

Step 6: Where no rent is paid, the owner's share of resource rent, and therefore of depletion, OCV, and stock value, is zero. The full Int$500 million depletion charge, the full Int$2,500 million OCV reconciliation entry, and the full closing stock value of Int$127,000 million remain with S.11, and S.13 records no balance sheet value for a resource it legally owns. This is not a separate rule; it is the zero-percent case of the same proportional split, and should be flagged in metadata since it likely understates public wealth.

F.7 Unresolved Questions

289. This annex does not resolve sector attribution where water rights are held communally or under customary tenure without a single identifiable legal owner, a common case for indigenous and traditional water rights regimes, nor where multiple government levels, national, state or provincial, and river-basin authority, share ownership of the same resource. Both require TC direction before the 2028 update and are proposed as an addition to the consultation questions in §5.3.