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Lower spring carryover and uneven downstream delivery in the Syr Darya, 2024–2026

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Abstract

Recent Syr Darya water accounts show lower spring carryover alongside uneven downstream delivery. We compare three consecutive institutional water accounts for October 2024–March 2026 and interpret their outcomes alongside water–energy agreements and operating decisions. Toktogul's closing storage changed from 0.42 km³ above plan to shortfalls of 0.53 and 0.38 km³. The summer 2025 shortfall combined inflow 0.22 km³ below forecast, releases 0.26 km³ above plan, and a −0.05 km³ balance deviation. In winter 2025–2026, releases exceeded plan by 0.54 km³ despite inflow exceeding forecast by 0.17 km³; the balance deviation was −0.01 km³. Actual end-winter storage was also 1.35 km³ lower than a year earlier, reflecting lower opening storage and inflow despite reduced year-on-year releases. Downstream performance separated further: in the latter winter, Shardara inflow reached 101.89% of plan while reported Aral supply reached 43.80%. The 0.68 km³ Aral shortfall comprised 0.63 km³ less river release from Shardara and 0.05 km³ greater lower-reach net depletion. These comparisons establish two concurrent outcomes: lower spring carryover and downstream delivery below target even when intermediate inflow met plan. Seasonal cooperation therefore faces distinct storage and delivery constraints whose location and timing determine the water benefit actually realized.

Keywords: Syr Darya; Toktogul; seasonal storage; downstream delivery; water–energy cooperation; Aral Sea

1. Introduction

Water–energy cooperation in the Syr Darya aims to reconcile winter electricity production with water available for summer irrigation. The physical exchange extends beyond the volume released from Toktogul. Water passes through additional tributaries, reservoirs, and withdrawal points before reaching lower-river users and the Aral Sea. Storage left at the end of one season also determines the starting resource for the next. A favorable result at one location or against one seasonal plan can therefore coexist with deteriorating outcomes elsewhere.

Recent records make this problem concrete. Toktogul released more than its displayed plan in three consecutive seasons between October 2024 and March 2026. Its end-winter storage nevertheless fell from 8.45 km³ in 2025 to 7.10 km³ in 2026. In the latter winter, inflow to Shardara exceeded plan while reported supply toward the Aral Sea fell substantially short (Nazarii et al., n.d.; Nazariy et al., n.d.; Scientific-Information Center of the Interstate Commission for Water Coordination [SIC ICWC], n.d.). These outcomes occurred during active water–energy exchanges: Kazakhstan's energy ministry reported more than

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1,560 million kWh delivered to Kyrgyzstan between September 2025 and April 2026 (Ministry of Energy of the Republic of Kazakhstan [Ministry of Energy], 2026).

This article asks what accounts for Toktogul's recent seasonal storage shortfalls and how those shortfalls compare with delivery outcomes farther downstream. It answers the question through a consecutive-season comparison of published reservoir and river balances, with separate comparisons against each plan and between actual winters. The principal finding is that the two recent storage shortfalls had different compositions, while the location of below-plan water supply also changed across seasons. Summer 2025 combined deficient inflow and above-plan releases at Toktogul with deficient inflow farther downstream. Winter 2025–2026 combined above-forecast Toktogul inflow with a larger release deviation, and above-plan Shardara inflow with below-plan river releases and Aral supply.

The contribution is an integrated reanalysis of seasonal and spatial divergence in the three published water accounts. It connects upstream carryover, intermediate inflow, and terminal supply within the same three reporting periods and separates performance against a moving plan from the amount of water actually carried forward. The comparison locates the storage and delivery shortfalls within those reporting periods. The discussion relates these outcomes to the region's established compensation and adjustment arrangements.

2. Cooperation and the physical outcomes of seasonal exchange

Bernauer and Siegfried (2008) established the importance of distinguishing compliance from substantive performance in the Naryn/Syr Darya regime. Their assessment compares actual outcomes with optimal and counterfactual benchmarks and emphasizes credible reciprocal energy commitments and multiyear storage. That work already provides the general conceptual distinction. The present study adds recent seasonal evidence on how different physical endpoints diverge under the operating plans that institutions themselves report.

Broader nexus research identifies the competing objectives surrounding these endpoints. Shi et al. (2021) connect water, energy, food, and ecological outcomes in the Syr Darya and Amu Darya through Bayesian networks. They identify temporal mismatch, including the imperfect correspondence between annual energy supply and water supply, as a limitation of aggregate comparison. Hu et al. (2026) evaluate allocation under climate and inflow scenarios using multi-objective optimization with conventional and seasonal pumped storage. Their results describe feasible trade-offs among prospective operating configurations. Our comparison examines realized quantities over matched six-month water intervals and tracks the resulting storage into the following season.

The 1998 Syr Darya agreement connects releases, electricity transfers, and compensation through annual coordination. Article II addresses releases, generation, transfers, and equivalent compensation for energy losses. Article IV provides for compensation associated with growing-season releases and multiyear storage through energy resources, other goods or services, or money by agreement. Articles V and VIII concern guarantees and annual approval of operating modes and energy transfers; Articles IX and XIV address dispute resolution and amendments (Agreement on the Use of Water and Energy Resources of the Syr Darya Basin [Syr Darya Agreement], 1998). The historical framework thus ties physical quantities to particular periods and reciprocal commitments.

Current decisions specify different institutional reference points. The 91st ICWC meeting approved withdrawal limits for the 2025–2026 non-growing season and took projected reservoir operations into consideration (Interstate Commission for Water Coordination [ICWC], 2025). The 93rd meeting followed the same distinction for the 2026 growing season and called for Kazakhstan and Uzbekistan to revisit Shardara inflow after agreement on Toktogul and Bakhri Tojik operating regimes (ICWC, 2026b). We accordingly

treat the reports' forecast/plan columns as physical comparison benchmarks. Legal obligations depend on the applicable agreement and its amendments.

3. Materials and method

3.1. Consecutive seasonal accounts

The quantitative evidence comprises the latest three completed seasonal analyses listed by SIC ICWC at the September 20, 2026 research cutoff: October 2024–March 2025, April–September 2025, and October 2025–March 2026. Selection follows consecutive completed periods, encompassing two non-growing seasons and the intervening growing season. Each interval covers six months. The unfinished 2026 growing season enters the institutional discussion through decisions and announcements only.

For Toktogul, we transcribed opening storage, inflow, releases, and closing storage from the forecast/plan and actual columns of Table 1.3 in each report. These 12 paired entries preserve the same reservoir boundary and km³ unit. Storage is a boundary-date stock; inflow and releases are seasonal volumes. The actual column reports institutional estimates of realized conditions. The summer 2025 report explicitly identifies its Toktogul data as calculated. Source PDFs and their table values are retained with the reproducibility materials.

We also transcribed seven endpoint quantities per season: Toktogul releases, lateral inflow and withdrawals upstream of Shardara, Shardara inflow, Shardara releases into the river, net depletion in the lower reach, and reported Aral supply at the Karateren gauge. Table 1.3 resolves the distinction between Shardara river releases and total discharge, which additionally includes direct reservoir withdrawals and, in some periods, diversion to Arnasay. The summer report uses a broader label in Table 1.2, but its 5.84/3.29 km³ pair matches the river-release row in Table 1.3. We consistently use that river-release pair. Net depletion follows each report's aggregate definition: withdrawals plus losses less lateral inflow; the 2024–2025 footnote additionally specifies Koksaray filling. The comparison preserves these reporting boundaries rather than treating depletion as a uniform measure of consumptive use.

The institutional corpus consists of the 1998 agreement, the 91st–93rd ICWC minutes, BWO Syr Darya's published operating procedures, four Kazakhstan energy-ministry announcements, and an account by Uzbekistan's first deputy water minister (Ishpulatov, 2026). We classify statements by actor, period, endpoint, quantity, and status: forecast, operating plan, reported agreement, reported delivery, or adjustment. The 1998 Russian text was checked against its available English translation. Current ministry announcements document reported exchanges and negotiations; detailed protocol annexes were unavailable.

3.2. Reservoir and downstream comparisons

For each season, the Toktogul account is:

$$S_1 = S_0 + I - Q + R, \tag{1}$$

where S_0 and S_1 denote opening and closing storage, I inflow, Q releases, and R the unallocated balance required to reconcile the displayed values. We calculate R separately for plan and actual quantities. Defining Δ as actual minus forecast/plan gives:

$$\Delta S_1 = \Delta S_0 + \Delta I - \Delta Q + \Delta R. \tag{2}$$

The same identity compares the two actual winter accounts, separating the changed opening stock from changes during the winter. This comparison distinguishes a deviation from that season's expected conditions from a change in physical resources relative to the previous year.

For the lower reach, reported Aral supply A is reconciled with Shardara river releases Q_r and reported net depletion D:

$$A = Q_r - D + U, \tag{3}$$

where U retains the unallocated difference between the displayed entries. Its deviation gives $\Delta A = \Delta Q_r - \Delta D + \Delta U$. Endpoint completion percentages equal actual divided by the stated forecast/plan or withdrawal limit. The connected endpoint rows overlap and are compared individually.

All calculations use decimal arithmetic and the displayed volume columns. The summer report prints differences as plan minus actual, whereas the winter reports use actual minus plan. Several printed difference entries also vary by 0.01 km³ from subtraction of their displayed operands; the extraction retains original values while the analysis recomputes differences consistently. R and U remain unassigned. The decompositions describe the composition of reported water balances; identifying operating motives, causal effects of energy imports, or contractual liability requires additional operational and agreement evidence.

4. Results

4.1. Two storage shortfalls with different seasonal compositions

Toktogul closed the first winter 0.42 km³ above plan, followed by a summer shortfall of 0.53 km³ and a second-winter shortfall of 0.38 km³ (Table 1). Releases exceeded plan in all three seasons. The difference between surplus and shortfall lay in the size and direction of the accompanying inflow and balance deviations.

Table 1. Toktogul seasonal accounts and closing-storage deviations

Panel A. Forecast/plan / actual volumes, km³

Season	Opening storage	Inflow	Releases	Closing storage
Oct 2024–Mar 2025	13.04 / 13.04	2.99 / 3.71	8.00 / 8.26	8.03 / 8.45
Apr–Sep 2025	8.45 / 8.45	9.34 / 9.12	5.89 / 6.15	11.90 / 11.37
Oct 2025–Mar 2026	11.37 / 11.37	2.88 / 3.05	6.78 / 7.32	7.48 / 7.10

Panel B. Actual-minus-plan contributions, km³

Season	Δ opening	Δ inflow	−Δ releases	Δ unallocated balance	Δ closing
Oct 2024–Mar 2025	0.00	+0.72	−0.26	−0.04	+0.42
Apr–Sep 2025	0.00	−0.22	−0.26	−0.05	−0.53
Oct 2025–Mar 2026	0.00	+0.17	−0.54	−0.01	−0.38

Note. Sources: Table 1.3, PDF p. 5 of each seasonal report (Nazarii et al., n.d.; Nazariy et al., n.d.; SIC ICWC, n.d.). Unallocated balances for plan and actual are respectively 0.00/−0.04, 0.00/−0.05, and +0.01/0.00 km³. Differences are calculated from displayed volumes.

In winter 2024–2025, the positive inflow deviation of 0.72 km³ exceeded the 0.26 km³ additional release and 0.04 km³ negative balance deviation. Summer 2025 combined two movements that both reduced storage relative to plan: inflow was 0.22 km³ lower and releases were 0.26 km³ higher. These comparable contributions, together with the −0.05 km³ balance deviation, formed the 0.53 km³ shortfall.

Winter 2025–2026 had a different composition. Inflow exceeded forecast by 0.17 km³, while releases exceeded plan by 0.54 km³. The additional inflow offset part of the release deviation, leaving the 0.38 km³ closing shortfall after the −0.01 km³ balance deviation. Release deviation therefore dominated this season's forecast-relative deficit (Figure 1). SIC ICWC (n.d., p. 1) attributes the above-plan releases to additional electricity generation at Toktogul and the Naryn cascade. This is the reporting institution's explanation of the operating outcome.

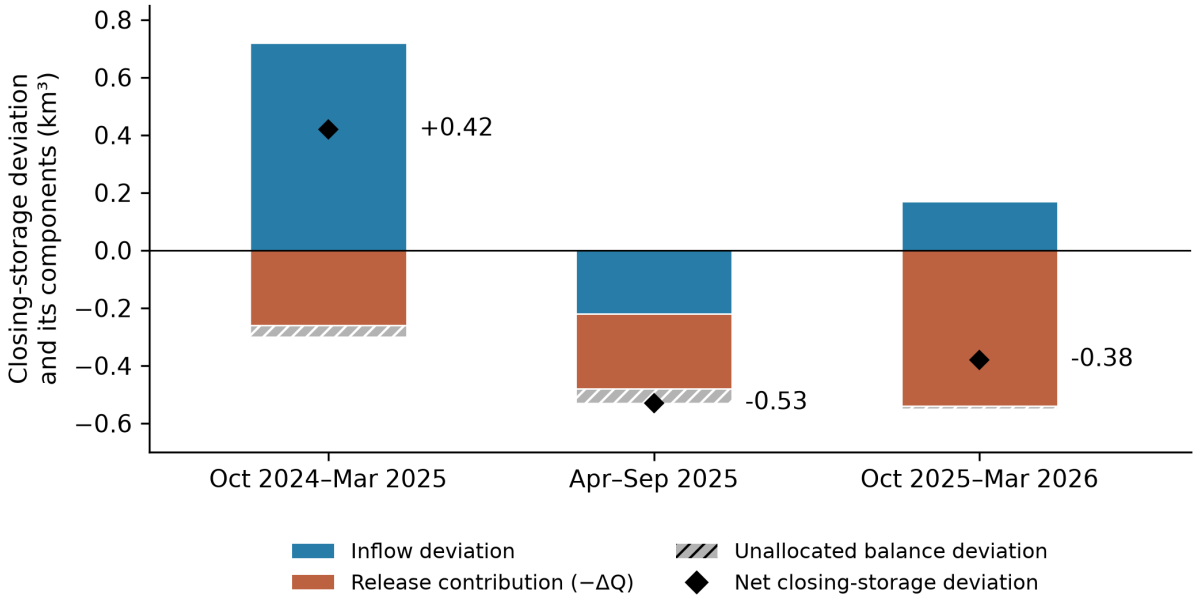


Figure 1. Contributions to closing-storage deviation from each seasonal forecast/plan. Bars show Δ inflow, −Δ releases, and Δ unallocated balance, with positive and negative contributions stacked separately. Diamonds show their algebraic sum. Opening-storage deviation is zero in each comparison. Unit: km³. Sources and calculations: Table 1.

4.2. Less water carried into spring despite lower winter releases

The actual winter comparison shows deterioration beyond the deviation from the latest plan. Toktogul entered winter 2025–2026 with 1.67 km³ less storage than a year earlier and received 0.66 km³ less inflow. Releases were also 0.94 km³ lower. The reduced outflow partly offset the smaller resource base, leaving end-winter storage 1.35 km³, or 15.98%, below the previous winter's close (Table 2).

Table 2. Change between actual Toktogul winter accounts

Component	Oct 2024–Mar 2025, km³	Oct 2025–Mar 2026, km³	Contribution to change in closing storage, km³
Opening storage	13.04	11.37	−1.67
Inflow	3.71	3.05	−0.66
Releases	8.26	7.32	+0.94
Unallocated balance	−0.04	0.00	+0.04
Closing storage	8.45	7.10	−1.35

Note. Release contribution has the opposite sign to the change in releases. Source quantities are the actual columns in Table 1. Closing-storage percentage change uses 8.45 km³ as the denominator.

Both comparisons matter for interpreting the latter winter. Inflow was better than that winter's forecast but 17.79% lower than the preceding winter's actual inflow. Releases were above the new winter plan but below the previous winter's actual releases. Thus, the physical deterioration combined an inherited storage disadvantage with a lower realized winter inflow, while the plan-relative shortfall was dominated by releases above the reduced schedule.

The transition between seasons explains how the inherited disadvantage enters the next account. Summer 2025 closed at 11.37 km³ against a target of 11.90 km³. The next plan adopted 11.37 km³ as its opening stock. Its subsequent 0.38 km³ shortfall therefore arose after the lower starting position had already been incorporated. The sequence records continuing pressure on carryover: summer accumulation fell short,

and the following winter ended below its revised baseline. The two seasonal shortfalls refer to different plans; Table 2 supplies a common actual-stock comparison across winters.

4.3. Downstream supply separated from upstream release completion

The three seasons show different combinations of endpoint performance (Table 3). In the first winter, Toktogul releases, Shardara inflow, and Aral supply all exceeded their respective plans. In summer 2025, Toktogul releases reached 104.41% of plan, while lateral inflow upstream of Shardara reached 68.95%, Shardara inflow 73.17%, and reported Aral supply 60.20%. The upstream reservoir's additional 0.26 km³ of releases coexisted with a 2.58 km³ lateral-inflow shortfall over the broader reach. Different source areas therefore experienced markedly different deviations during the same season.

Table 3. Seasonal endpoint volumes and completion relative to each benchmark

Indicator	Oct 2024–Mar 2025	Apr–Sep 2025	Oct 2025–Mar 2026
Toktogul releases	8.00 / 8.26 (103.25%)	5.89 / 6.15 (104.41%)	6.78 / 7.32 (107.96%)
Lateral inflow upstream of Shardara	10.44 / 11.32 (108.43%)	8.31 / 5.73 (68.95%)	9.24 / 9.48 (102.60%)
Withdrawals upstream of Shardara	4.25 / 3.92 (92.24%)	11.88 / 9.30 (78.28%)	4.22 / 3.85 (91.23%)
Shardara inflow	10.94 / 13.36 (122.12%)	3.69 / 2.70 (73.17%)	9.51 / 9.69 (101.89%)
Shardara releases into the river	6.42 / 6.76 (105.30%)	5.84 / 3.29 (56.34%)	4.63 / 4.00 (86.39%)
Lower-reach net depletion	4.75 / 4.97 (104.63%)	4.87 / 2.70 (55.44%)	3.42 / 3.47 (101.46%)
Reported Aral supply at Karateren	1.67 / 1.79 (107.19%)	0.98 / 0.59 (60.20%)	1.21 / 0.53 (43.80%)

Note. Each cell gives forecast/plan or limit / actual, in km³, followed by actual as a percentage of that benchmark. Sources: Tables 1.1–1.3 of the three seasonal reports. Withdrawals are compared with limits, while the remaining rows use the displayed forecast/plan. Desired directions depend on the indicator; percentages are quantity comparisons. The Aral endpoint follows the reports' Karateren gauge definition, described as supply to the Aral Sea and region in summer 2025. Rows overlap spatially and are not additive.

In winter 2025–2026, the divergence moved farther downstream. Shardara received 9.69 km³ against a plan of 9.51 km³, yet released 4.00 km³ into the river against 4.63 km³. Reported Aral supply was 0.53 km³ against 1.21 km³. For this reach, the source quantities reconcile directly: the 0.68 km³ terminal shortfall consists of 0.63 km³ less river release and 0.05 km³ more reported net depletion. The release component accounts for 92.65% of the displayed shortfall. This is an arithmetic share of the water account, with net depletion incorporating withdrawals, losses, and lateral inflow.

The summer lower-reach account differs. River releases from Shardara were 2.55 km³ below plan, while net depletion was 2.17 km³ below plan. The latter offset most of the former, leaving an Aral shortfall of 0.39 km³ after a −0.01 km³ balance deviation. The smaller summer terminal shortfall therefore accompanied a much larger release shortfall than the following winter. Its reduced lower-reach depletion explains that difference in the displayed account.

Withdrawal completion represents another distinct outcome. Summer withdrawals upstream of Shardara were 2.58 km³ below limits; winter 2025–2026 withdrawals were 0.37 km³ below limits. The latter report attributes low Kyrgyz and Tajik withdrawals to an absence of requests (SIC ICWC, n.d., p. 2). Unused authorization and curtailed requested supply consequently require separate interpretation. The February 2026 ICWC request for withdrawal data in the Bakhri Tojik–Shardara reach addresses this need for spatially specific information (ICWC, 2026a).

4.4. Energy deliveries accompanied continued storage pressure

The September 2025 trilateral announcement linked Toktogul releases to electricity supplied by Kazakhstan and Uzbekistan to Kyrgyzstan (Ministry of Energy, 2025a). The November announcement described winter deliveries intended to support storage for the 2026 irrigation season and reported an

agreed protocol specifying delivery and storage parameters (Ministry of Energy, 2025b). Kazakhstan subsequently reported more than 1,560 million kWh delivered over September 2025–April 2026 (Ministry of Energy, 2026).

These announcements establish an operating exchange during a period that includes the winter storage shortfall. The reported electricity window covers eight named months, while the water account covers six. Matching that delivery to a compensation completion rate would require the contractual target and monthly allocation. Estimating its effect on releases would additionally require a counterfactual dispatch analysis. The empirical observation is that energy transfers were reported and storage still ended below the stated seasonal target.

Negotiation continued into the next season. A subsequent Tashkent announcement reported agreed releases for the next two months and a planned June meeting for July–September scheduling (Ministry of Energy, n.d.). Ishpulatov (2026) reports that the three countries met in Bishkek on June 20 and signed a further protocol covering water releases and reciprocal electricity supply. Together with the 93rd ICWC decision to revisit Shardara inflow after agreement on upstream operations, this sequence documents staged revision of operating arrangements.

5. Discussion

5.1. Storage pressure changed between seasons

The comparison identifies a change in the composition of Toktogul's shortfall. Summer 2025 combined lower inflow and higher releases relative to plan; winter 2025–2026 combined favorable forecast-relative inflow with a larger release deviation. The second pattern places the immediate plan-relative imbalance on the outflow side of the account. SIC ICWC's explanation of additional hydropower generation gives an institutional interpretation consistent with that result.

The actual winter comparison adds the physical context. The later winter began with less water and received less inflow than the earlier winter. Lower year-on-year releases mitigated those disadvantages, but closing storage remained almost 16% lower. This explains how a season can simultaneously have above-forecast inflow, above-plan releases, and declining water availability compared with the previous year. A forecast-relative performance judgment and an assessment of the resource carried into spring answer different substantive questions.

This result extends the storage concern in Bernauer and Siegfried (2008) with a recent linked sequence. Their work establishes why multiyear management matters; the present accounts locate the observed deterioration across a summer accumulation period and the following winter. The sequence makes the size of the inherited stock disadvantage explicit and distinguishes it from the additional deviation within the new season.

5.2. The water benefit depends on where delivery is assessed

The strongest spatial result is the 2025–2026 winter contrast between Shardara inflow above plan and Aral supply below half of plan. Summer's widespread inflow deficits offer a straightforward physical context for downstream scarcity. The following winter shows that satisfying the intermediate inflow benchmark still left a large terminal shortfall. Its lower-reach account places most of that shortfall in below-plan river release from Shardara, with a smaller contribution from increased net depletion.

The result sharpens the distinction between releases supporting an upstream energy exchange and water arriving at a downstream endpoint. Reservoir-outlet volume, intermediate inflow, irrigation withdrawals, and terminal supply convey different benefits. Hu et al. (2026) include agricultural, energy, and ecological objectives in allocation optimization; these observed seasonal divergences show why those objectives also need separate interpretation when assessing actual operation. A single upstream comple-

tion percentage would conceal the winter combination of continuing storage pressure and weak terminal delivery.

The policy implication is to tie each operating commitment to its intended physical outcome. Preserving spring carryover requires an end-storage objective as well as a release schedule. Supporting a downstream delivery requires a specified location and interval. In the winter studied, additional upstream release and adequate intermediate inflow coexisted with a terminal shortfall; achieving one of those quantities did not secure the others. Compensation that rewards a defined release can therefore coexist with an unmet downstream supply objective unless the agreed exchange explicitly covers that endpoint.

5.3. Implications for seasonal adjustment and compensation

The 1998 framework accommodates annual agreements and several forms of reciprocal compensation. Recent staged negotiations likewise provide room to change operating schedules as water and energy conditions develop. BWO Syr Darya's published procedure recognizes correction of withdrawal limits and refers changes exceeding 10% of the total to an ICWC meeting (BWO Syr Darya, n.d.). That specified authority concerns withdrawal limits; compensation and reservoir commitments follow their own agreed terms.

Our findings give those adjustments a concrete physical content. The summer storage deficit combines changed resource availability with additional outflow. The winter deficit combines additional outflow relative to plan with an already reduced starting stock. The terminal winter deficit appears downstream of an intermediate location where the inflow target was met. Each situation concerns a different objective and reference point, so the associated adjustment must specify which stock or delivery quantity the parties accept, restore, or revise.

The reported electricity deliveries matter because they show that exchange was occurring while these constraints persisted. Their coexistence directs attention to the outcome secured by the agreement, its timing, and its benchmark. A subsequent plan correctly begins with observed storage; an agreed revision can also change the target or settle an earlier commitment. The water-account evidence identifies the physical consequence to be addressed, while the applicable protocol determines its contractual treatment.

5.4. Evidence and interpretation

This is a descriptive case comparison of three consecutive institutional accounts. It retains estimated quantities, source precision, and unallocated terms, including the summer qualification that Toktogul data were calculated. Some lower-reach quantities may be derived within the same institutional balance; their arithmetic fit is therefore a reconciliation of reported entries, not independent validation of the hydrology. The different depletion definitions also limit interpretation of its change as a change in a single physical process.

Seasonal aggregates identify the amount and location of shortfalls but leave within-season timing, water quality, farm-level receipt, and ecological damage unresolved. Confidential protocol annexes, amendment histories, dispatch records, and reconciled energy invoices were outside the available evidence. Consequently, the results assess physical outcomes against displayed plans and across actual seasons. They support the stated storage and delivery findings while leaving the causes of individual operating decisions and legal responsibility to evidence at the appropriate scale.

6. Conclusion

Toktogul's consecutive storage shortfalls had different water-balance compositions. Summer 2025 combined below-forecast inflow with above-plan releases, producing a 0.53 km³ closing deficit including the unallocated term. Winter 2025–2026 ended 0.38 km³ below plan even with inflow 0.17 km³ above

forecast, because releases exceeded plan by 0.54 km³. Across the two actual winters, lower opening storage and inflow outweighed reduced releases: the water carried into spring fell by 1.35 km³, or 15.98%.

Downstream delivery also diverged from upstream performance. In winter 2025–2026, Shardara inflow reached 101.89% of plan but Aral supply reached only 43.80%. River releases 0.63 km³ below plan and net depletion 0.05 km³ above plan accounted for the 0.68 km³ terminal shortfall. The observed problem was thus concurrent pressure on upstream carryover and downstream delivery, with different seasonal and spatial compositions. The water benefit realized by seasonal cooperation depended on both the stock retained for the next season and the volume reaching the specified downstream location.

7. Data and reproducibility

The accompanying materials preserve the original seasonal reports, transcribed reservoir and end-point tables, source locators, and decimal-arithmetic scripts. The original script reproduces the Toktogul plan-relative accounts; the additional analysis reproduces the winter-to-winter comparison, all 21 end-point entries, and the lower-reach reconciliations. Figure 1 retains the unchanged reservoir decomposition. These materials use published institutional estimates; the study collected no new gauge measurements or interviews.

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