

Reading the Alaknanda: a reservoir delta, a railway tunnel and a sinking town

Sediment, rock and water set the limits on what can be built in the Alaknanda valley, and the landscape shows those limits before any report does.

ICED Field School in the Himalaya 2026 · Day 2, Monday 13 October 2026

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Between Srinagar and Joshimath, the Alaknanda climbs out of the Lesser Himalaya into the Main Central Thrust zone (Fig. 1). We stopped three times, and each stop showed one way in which the valley answers back to engineering: a reservoir filling from its upstream end, a railway driven through the mountain because the surface is unsafe, and a town moving on the landslide debris it was built on.

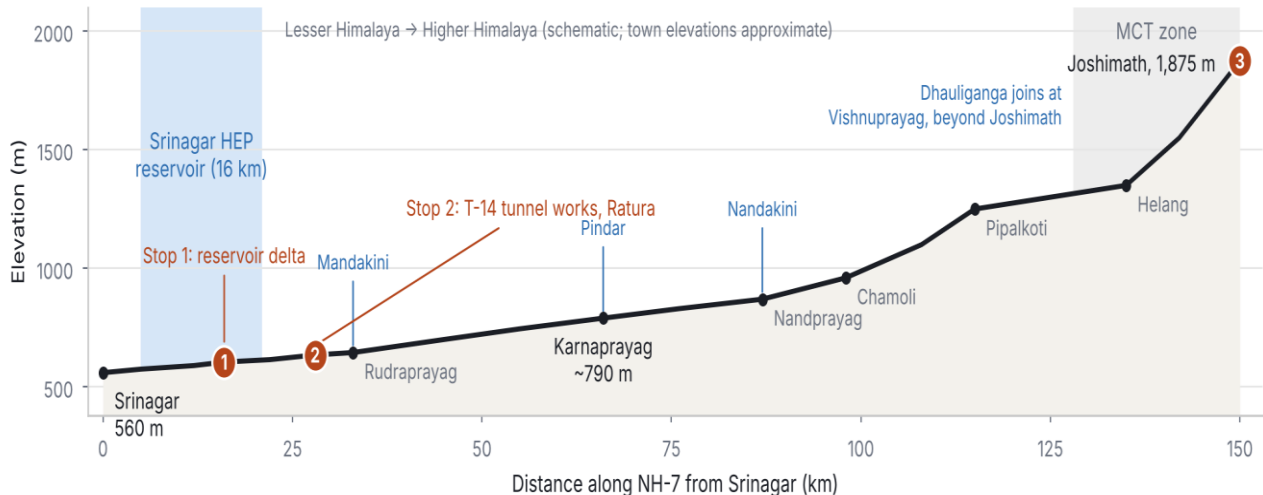


Fig. 1. Schematic road profile from Srinagar to Joshimath with the three stops. Town elevations and reservoir length are approximate; thrust position after the excursion guide (Mey, 2026).

1. Srinagar: a delta growing inside a reservoir

Observations. Our first stop was a bar on the Alaknanda upstream of Srinagar, where the river enters the 16-km reservoir of the 330 MW Srinagar hydroelectric project (90 m dam, impounded 2015). The bar was broad and flat, built of pale, well-sorted fine sand with no gravel on its surface (Fig. 2), and the water beside it was wide, smooth and almost still, nothing like the boulder-bedded, white-water channel we saw at Karnaprayag later in the day (Fig. 3).

Interpretation. On the long profile a dam is an anthropogenic knickpoint (guide, Fig. 15): the gradient flattens upstream, so the river deposits, and steepens below, so it scours. In the ponded reach the load is sorted by settling velocity. A 0.2 mm sand grain settles at about 2 cm/s and a 0.02 mm silt grain at about 0.03 cm/s (Ferguson & Church, 2004), so in 10 m of water the sand is on the bed within minutes while the silt stays up for about eight hours and rides on toward the dam. The sand we stood on is therefore the topset of a delta at the head of the reservoir, built in little more than a decade since impoundment. The valley has filled before: terraces at Choras, opposite Srinagar, record aggradation between about 18 and 6 thousand years ago, then incision (Juyal et al., 2010). For the operator the delta is live storage lost; for the valley it is a bed rising upstream of the dam, so the same flood discharge reaches a higher stage. Prof. Axel Bronstert used the site to revisit the June 2013 flood, when more than 300 mm fell in 24 hours above Kedarnath and Badrinath (guide, Fig. 24) and fine sediment up to 7–8 m thick was left in Srinagar town: the delta we stood on is the slow, everyday version of that one-day deposit.

Open question. How fast does the delta front advance each monsoon, and what share of the live storage has it already taken? A repeat survey of the bar would give the first number.



Fig. 2. Stop 1, above Srinagar. The bar is the topset of a delta forming where the Alaknanda meets the ponded water of the Srinagar HEP reservoir. People for scale.

2. Ratura: tunnel T-14 of the Rishikesh–Karnaprayag railway

Observations. Near Rudraprayag we visited the works for tunnel T-14 (about 6.5 km), one of 16 main tunnels on the 125-km broad-gauge line. The site is a portal yard: a drilling rig, muck trucks and the cut slope above the portal. Except for the twin tunnels between Devprayag and Janasu, bored largely by TBM, the line is driven by drill-and-blast (NATM): the rig drills the blast holes, the round is fired and mucked out, and the fresh face is sealed with shotcrete and rock bolts, with steel ribs where the rock is weak, before the next round begins.

Interpretation. 104 of the line's 125 km are in tunnel, with 98 km of parallel escape tunnels. The alignment reads as a direct answer to the valley: a line on the valley floor would sit in the flood channel we had just stood on (Fig. 3), and a line cut into the hillside would face the slopes of NH-7, where Mey et al. (2024) mapped more than one landslide per road kilometre, concentrated in the phyllites between Rishikesh and Srinagar and the limestone and shale between Pipalkoti and Joshimath; our own stretch, Srinagar to Pipalkoti, is the quietest part of that inventory. Underground the engineering questions change rather than disappear: rock-mass class, shear zones and water inflow at the face decide how far each round can advance before support goes in.

Fig. 3. Karnaprayag, just below the Pindar confluence, seen from the road.



3. Joshimath: a town on old landslide debris

Observations. Joshimath sits on the slope above Vishnuprayag, where the Dhauliganga joins the Alaknanda, in the Main Central Thrust zone. Following the day's theme in the guide, we split into groups and interviewed residents about the movement that made national news in January 2023 (Fig. 4). Their explanations fell into two groups. Most pointed to the pace of building in and around the town and to the water that now moves through it; some gave a religious one: the Nar and Narayan mountains are closing in, and when they meet the seat of Badrinath will move to Bhavishya Badri.

Interpretation. The geological explanation has three parts, and the residents' answers map onto them. First, the ground: as early as 1976 the Mishra Committee described the town as standing on a thick, poorly consolidated mass of old landslide debris over the gneisses and schists of the Joshimath Formation. The terraces the road climbs at Pipalkoti tell the same story: dated to about 10 thousand years ago, they are attributed partly to ponding behind a landslide dam (Juyal et al., 2010). Second, water: whatever enters the debris, from rain, springs, drains or leaking supply lines, lowers its strength, and the steep streams that cross the town cut into it. Third, the toe: the Alaknanda and Dhauliganga erode the base of the slope. Building load and water are the two variables people can see; the debris and the rivers are the ones that set the stage. The InSAR record makes the water link visible: between 27 December 2022 and 8 January 2023 ISRO measured 5.4 cm of movement in 12 days against a background rate of about 6.5 cm a year, the kind of pulse a saturated debris mass gives after a wet spell. The Nar–Narayan legend is older than any of the reports. Read as a record rather than a prophecy, it says what the instruments now say: the slope has always been moving.

Open question. Can InSAR time series separate the seasonal, water-driven part of the movement from permanent creep, and what would a “carrying capacity” for the town mean in engineering terms: a load limit, or a limit on the water entering the debris?



Fig. 4. Regrouping before setting out for field survey, with the slopes above Joshimath rising behind us.



Fig. 5. Stop 3, Joshimath: our sub-group interviewing a resident about the ground movement and how it has affected daily life.

Reflections

What we learned. Sediment is the thread: the delta at Srinagar, the muck at Ratura and the debris under Joshimath are the same material at different stages of its journey downstream. **What surprised us.** That a reservoir delta is something you can stand on, and how closely residents' everyday explanations track the geology. **How the field changed our understanding.** Trap efficiency, support classes and subsidence rates are desk numbers; here each had a location and a person affected by it.

Key takeaways

- **A reservoir fills from the top.** The delta is the first storage lost and the first flood level raised.
- **Himalayan infrastructure does not avoid hazards; it chooses which ones to face.** A tunnel trades surface landslides for rock-mass and groundwater questions at the face.
- **Joshimath's situation starts with its foundation.** Drainage, toe protection and load management all follow from the debris the town stands on.

References. [Ferguson, R.I. & Church, M. \(2004\) A simple universal equation for grain settling velocity. J. Sediment. Res. 74, 933–937](#) · [Juyal, N. et al. \(2010\) Late Quaternary fluvial aggradation and incision in the Alaknanda valley. J. Quat. Sci. 25, 1293–1304](#) · [Mey, J. \(2026\) Excursion guide, ICED Field School in the Himalaya. University of Potsdam / IIT Roorkee](#) · [Mey, J. et al. \(2024\) More than one landslide per road kilometer. Nat. Hazards Earth Syst. Sci. 24, 3207–3223](#) · [Ministry of Railways reply, 29 Jul 2026 \(Swarajya\)](#) · [PTI, 2 Jul 2025, on the TBM tunnels \(The Week\)](#) · [Mongabay-India, Jan 2023, on ISRO's InSAR](#) · [Wikipedia: Joshimath \(accessed Oct 2026\)](#).