Living With the Stehekin River in the aftermath of the December 2025 Flood

A report by Paul Bakke[1]
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Report overview

The flood of December 11, 2025 was the second largest in the 105-year record of water discharge in the Stehekin River. It is currently estimated to have been 21,500 CFS (cubic feet per second). This was exceeded only by the 26,000 CFS flood of October 20, 2003. The flood has caused much damage to infrastructure (roads, power) and buildings, particularly along the Company Creek Road. As of this writing, part of the river continues to flow through the neighborhood of houses accessed by this road, following a network of old channels on the floodplain that had not been occupied by the river flow for many years, possibly never since modern settlement. The purpose of this report is to give a brief scientific perspective on how mountain rivers, and the Stehekin River in particular, function and change over time. Next, I will discuss how the segment of the river and valley between the upper end of the Company Creek Road (River Mile 6.5) and the Company Creek alluvial fan (River Mile 4.7) is distinct. This is the area in which a portion of the river flow has changed channels and continues to flood houses and the road.

I will then discuss evidence for why the river is different now than it was 60 years ago. The river is less stable now than it was back then, and appears to be in a period of transition as it adjusts to changes in climate and sediment load.

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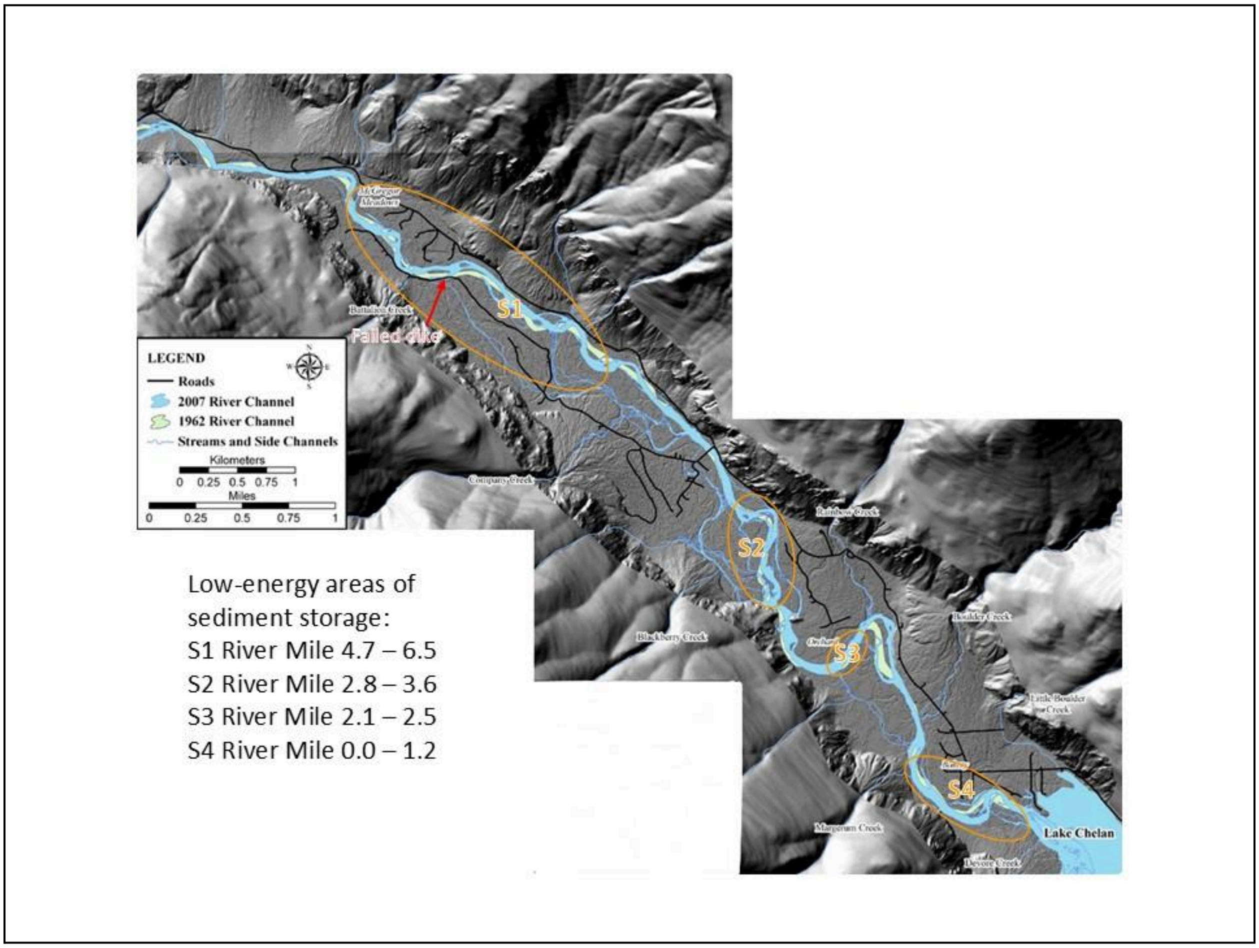
[1] Paul Bakke is a river scientist. He has 11 years of experience as a hydrologist for the U.S. Forest Service in Oregon, and 19 years experience as a geomorphologist with the U.S. Fish and Wildlife Service in Washington State. He is a licensed geologist in Washington, and holds degrees from the University of Washington, Seattle University and Oregon State University. He has been observing the Stehekin River ever since working in Stehekin as a Seasonal Park Ranger in the 1980's. Currently, he works as a consultant in the design of river restoration projects.

He volunteered to produce this report at the request of several valley property holders.

Finally, I will describe an array of possibilities to respond to the flooding, discussing relative cost, and what the science says about the risk of failure to achieve goals and the risk of unintended impacts to the river, the habitat and surrounding lands upstream and downstream. I want to emphasize that none of these actions are certain of restoring the conditions that existed before the flood.

With that in mind, I hope to convey understanding that rushing into a costly, high-impact option is imprudent and risky. The Stehekin River deserves to be treated with careful consideration of what the science says and measured consideration of long-term as well as short-term consequences. I hope that any actions will fully reflect the value of the river and the Stehekin Valley as a place of special beauty and natural wonder in harmony with human presence.



(Map of the lower Stehekin Valley, showing low-energy sediment storage zones discussed later in the text. Channel migration between 1962 and 2007 is indicated.)

How Rivers Function

As water flows downstream, it is constantly dissipating energy, using up the energy it contains by virtue of gravity. To flow, it has to first overcome friction along the channel boundaries (the streambed and streambanks). The water isn't sliding frictionlessly downstream – it is actually scraping along the streambed as it flows, exerting a frictional force on the gravel and sand making up the top of the streambed.

Next, the flowing water must overcome internal resistance as it moves around corners, bars, logs, trees, tree roots, boulders and other objects that create turbulence. Turbulence burns energy, slowing the water's movement downstream.

If, after this, there is still energy left, the flowing water can then erode sediment (gravel, sand, cobbles) from the channel boundaries, mainly, the streambed. If the water is flowing swiftly in areas very near the streambank, it may erode sediment from the bank, also. But, objects near the bank, such as tree roots, can slow the water as it approaches the bank, slowing the erosion. Erosion is strongest in areas that are deepest. That's how pools form.

Finally, if after eroding the streambed there is still energy left, the flowing water can then move (transport) the eroded sediment downstream. As the sediment is carried downstream, it eventually will reach an area where the energy available is no longer enough to transport it further. The sediment then is deposited on the streambed. This will happen if the flowing water moves into a wider place, or if it moves into a place that is less steep (less gravitational energy).

This brings up an important but often-overlooked fact about rivers: they don't just move water. Rivers also move sediment, and in forested areas, they move large wood pieces (logs, whole trees). All three of these flows of material are strongly interrelated.

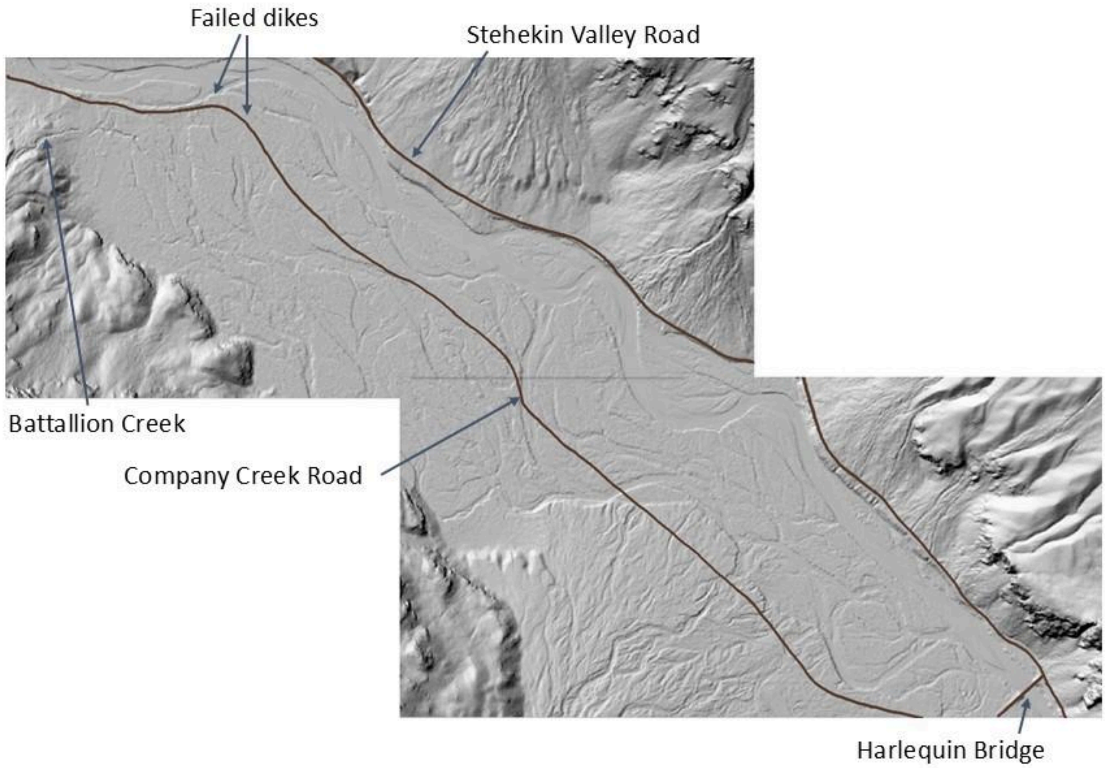
The Stehekin moves lots of sediment, about 32,000 cubic yards per year, on average, but in some years, it could easily be twice that amount. This is less than many of the big rivers on the western slopes of the Cascades, but it is still a lot for a river with only 344 square miles of watershed. The sediment ranges in size from boulders to basketball-sized cobbles to golf-ball-sized gravels to sand and, finally, microscopic silt and clay particles. The silt and clay are carried in suspension while the larger grains bounce, slide and roll along the streambed.

Most sediment movement occurs during peak discharges – floods, or at least, storms – when the river has the most energy to expend. Obviously, it takes more energy to move a basketball-sized cobble than a grain of sand, so these larger sediment "grains" are in motion less often and are carried less far by a given storm. The larger gravels and cobbles are deposited in the channel in low-energy areas, waiting for the big floods to move them downstream. Essentially, the river puts them in "storage." These deposits of larger grains can be stored for a long time – decades, even centuries – as the river finds other pathways to flow around them.

All of the rivers coming out of the Cascade Mountains have these “low-energy” areas, where the river flows from a steeper, narrower part of its valley into an area where the valley bottom is wider and less steep. The Stehekin River has several of these low-energy areas, but the most important one is the area between the upstream end of the old McGregor Meadows development and the widest part of the Company Creek alluvial fan, just upstream from Harlequin Bridge (River Mile 4.7 – 6.5, labelled S1 on the map, above).

This is the first low-energy area encountered by sediment moving downstream from the upper valley during a big flood, so this is where much of that sediment, particularly the larger grains, get deposited, forming extensive gravel and cobble bars. It is also where logs and other pieces of large wood tend to deposit as the current gets shallower, and as the opportunity increases for logs to become wedged against the inlet to an active side channel. As the river builds gravel/cobble bars and creates logjams, it must expend ever more of its energy moving around and over them, energy that was otherwise being used to transport sediment.

The reason this part of the valley is prone to flooding, bank erosion and sudden shifts in which channel carries the flow is because of this natural process of depositing logs and sediment, putting them in storage, and changing course in response to them. The network of old river channels visible in this part of the valley in the LIDAR imagery of the flood-prone area is evidence that these processes have been going on for a very long time. These channels are actually not just part of the “100-year floodplain,” but part of the river itself, even if they haven’t been occupied by river flow in recent memory. This is the most dynamic part of the river – the place where rates of bank erosion and shifting flow location are the greatest.



(LIDAR image of the area between Harlequin Bridge and the upper Company Creek Road. The location of the failed dikes where the river overflows its main channel is shown. Notice the complex network of old river channels throughout the area. The Company Creek alluvial fan is visible just below center.)

Some Facts to Keep in Mind While Considering River Management Options

With that introduction, I will now shift to a brief tally of several facts that come from the science of how rivers work.

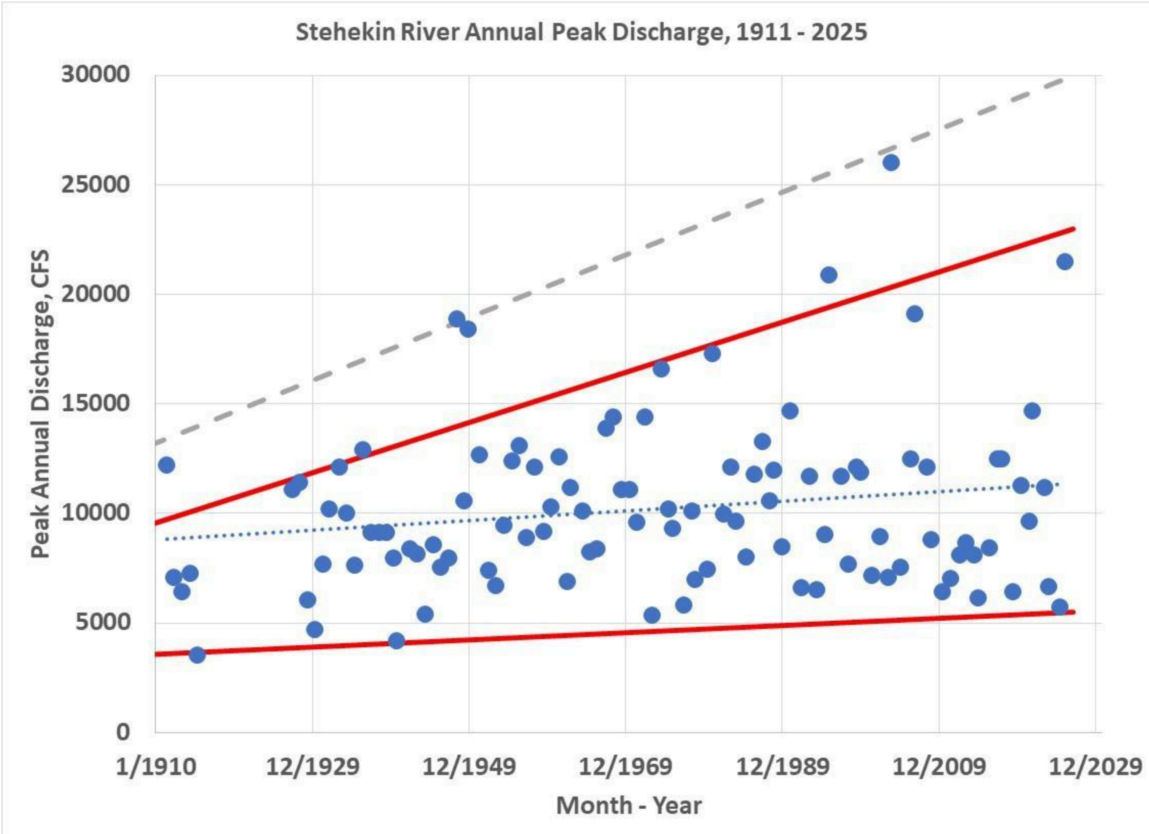
1. The shape of a river channel, that is, its width, depth, downstream slope, and the way it curves or meanders is not random. Rivers adjust their shape to balance out their energy dissipation, and to balance the movement of sediment through erosion and dissipation.
2. All rivers migrate, that is, change the location of the channel over long periods of time. This means that some level of bank erosion will always be happening. Bank erosion is not a sign of instability, unless it becomes excessive.

3. The proportion of cobble, gravel and sand in the streambed is not random. It is a result of a balance of erosion and deposition of sediment. The surface layer becomes coarsened in this process, in a way that helps establish this balance. Disrupting the surface layer destabilizes the streambed, causing it to erode.
4. The energy dissipation rate of the flowing water is greater if the channel becomes deeper, if it gets narrower, or if it gets straighter. If the energy dissipation rate increases, erosion results.
5. Straight river channels are inherently unstable and are almost never seen in nature. A straightened channel will inevitably evolve back to a meandering, curved channel.
6. If you alter the river to move more sediment downstream, that sediment will deposit in the next low-energy zone downstream, causing instability as the channel adjusts to it there. Downstream of Harlequin Bridge are three other low-energy zones:
    a. the area upstream of the Buckner Orchard (River Mile 2.8 - 3.6, labelled S2 on the map, above)
    b. the area just upstream of the Rainbow Creek confluence (RM 2.1 - 2.5, labelled S3).
    c. The area between the river mouth and the Margerum Creek alluvial fan (RM 0.0 - 1.2, labelled S4).

    All of these areas show networks of old side channels and recent channel shifts (channel migration), as does the currently-flooded zone. To make matters worse, when the PUD constructed the hydroelectric dam at Chelan in the 1920’s, the lake level was raised by about 20 feet. The river in the two downstream low-energy areas, S3 and S4, is still adjusting to that increased water level. Increasing the water level in the lake reduced the available energy of the river water, by reducing its total fall. This causes increased sediment deposition and potentially increases the channel migration and bank erosion rates. Currently, these two areas are not as “dynamic” as the low-energy zone upstream from Company Creek, but they could become dynamic again with increased sediment from upstream.

7. *****IMPORTANT!***As our climate changes, the Stehekin River has changed. Solutions that worked in the past won’t work now.** Because of increased flood frequency and intensity, trying to put the river "back where it was," or doing something that seemed to work 60 years ago - like dredging - is no longer going to be effective. It is a different river now, with bigger floods and more sediment movement than during the period of relative “calm” between the 1948 flood and the 1996 flood. This statement requires some elaboration.

    Here is a graphic showing the annual peak water discharge for the Stehekin River.



This graphic shows the record of 105 annual peak flows over a time span (period of record) of 115 years (1916 - 1926 are missing). The statistical average trend line (blue dotted line) shows that the average peak discharge is steadily increasing, at a rate of 218 CFS per decade, for a total increase in the average peak discharge of 2,488 CFS over the period of record.

But more disturbing are the "outer envelope" lines, which are like statistical confidence intervals. The outer envelope is getting broader over time, as the storms which drive these peak flows get more powerful, more erratic. The grey upper line is sort of a 99 percent confidence interval. The more "conservative" red lines are sort of a 95 percent confidence interval. As you can see, the December 2025 flood of 21,500 CFS was not unexpected, based on these trends. And if the upper (grey) line is accurate, we can expect a 30,000 CFS flood sometime in the next decade or two, which would cause far more damage and hardship than last December's flood has caused.

The reason for these trends seems to be a shift from spring snowmelt floods (e.g. the infamous 1948 flood) to autumn/winter rain-on-snow floods driven by atmospheric rivers. In the total record, there are 20 autumn/winter floods. Sixteen of the 20 - or 80 percent - occurred in the second half of the period of record, that is, since 1974.

Rain-on-snow floods are much “flashier,” that is, the floodwater is concentrated into a shorter period of time, reaching a higher maximum. Snowmelt floods, by contrast, spread the floodwater over a longer-duration, broader and lower peak.

8. **Along with an increase in the average peak discharge and the erratic variability of those peaks, there has been an increase in the sediment load.** This is another consequence of our changing climate. The current trend in increased sediment deposition and storage in the low-energy area upstream of Company Creek was worsened by a big pulse of sediment that originated from erosion along the (former) upper valley road upstream from Tumwater Bridge in the October, 2003 flood. This sediment, along with sediment from other natural sources upstream, deposited at the upstream end of the current flood zone, at the upstream end of McGregor Meadows (River Mile 6.5). It was held in place by a big log jam that formed there in the same flood event. Eventually, that logjam broke up, and the sediment behind it is now making its way downstream through the reach, filling in the channels and destabilizing the river.

   The point is, however, that December 2025 was not a one-off event. As the climate changes, the energy available to pick up sediment and carry it downstream is now greater than it was 60 years ago. These stronger and more frequent floods will expose new sediment sources to erosion, and destabilize existing long-term sediment sources (for example, the large, chronically eroding hillslope near Shady Camp), causing increased and more frequent delivery of sediment to the flowing water.

   Therefore, again, the river now is not the river it used to be! It will be in a state of instability for a long time in those areas that are most sensitive to changes in energy dissipation and sediment load. The currently flooded reach between RM 6.5 and RM 4.7 is one of these areas.

Options for Living with the River

I will now discuss several options that have been suggested for responding to the December 2025 flood. My intent is to focus on long-term costs and sustainability in addition to short-term issues. This discussion treats the river as something of value, something worth protecting, that should not be destroyed in the name of continuing to live with it.

1. **Construct flood fencing.**
   Flood fences are low-profile structures consisting of rows of short piling, perpendicular to the flow, built on the gravel bars and shallow or dry edges of the channel.

(Photo: Flood fence on the Skykomish River, Washington)

During high water, flood fences catch or strain out woody debris and large cobbles, but are low enough that they don't cause the flow to back up the water or cause scouring. Instead, they create high spots on the channel edge, coaxing the main flow back into the middle of the channel. By putting in enough of these and starting well upstream of the eroding area, it is possible to modify the channel shape, giving it a narrower, deeper central area surrounded by higher gravel bars on the edges. This creates a more concentrated flow in the middle of the channel that keeps more sediment moving, and steers it more efficiently past the widened area that was filling in with sediment, and past the nearly 90-degree bend at the road washout/dike failure site (RM 5.9) that the flow could not negotiate without putting extreme pressure on the side channel, the now-failed dikes, and the road.

This is a long-term managed solution that would not, in itself, restore the river to its former main channel. That would be an expected long-term effect. Short-term action would be needed concurrently to repair the failed dikes and road, to create permanent road crossings on the flood channels (possibly building up the road bed) and fixing those houses that can be protected from future flooding.

This option would work with, rather than fight, the natural processes of the river. It would leave the river and adjacent habitat unimpaired, and have minimal visual impact for residents and Park/Recreation Area visitors.

2. **Construct engineered logjams in the flood-prone reach**.
   An engineered logjam is just that – an artificially-constructed jog jam, anchored and bound together so that it won't move, designed to keep a central channel scoured for holding most of the flow, while routing the sediment load through the reach, instead of depositing within the reach.

   This option could allow the community, or at least most of it, to remain in the neighborhood along Company Creek Road within this flood-prone part of the valley. The cost of engineered logjams would be high (comparable to dredging and diking) but this would be a long-term, broad scale solution.

   Some periodic maintenance would be necessary, such as reconfiguring logs that catch on the logjams and alter them, perhaps using this large wood to create new logjams in key places. Logs moving in from upstream would become caught on the engineered logjams rather than piling up at side channel entrances and creating a risk of rapid capture of the main flow by the side channel. New logs caught from upstream would not need to be removed, only moved.

   The engineered logjam option works with the natural processes of water and sediment flow, and movement of large wood, rather than trying to fight these processes. There would be periodic maintenance costs, but these actions would not have a detrimental effect on the river habitat, and over the long term, would be less than the costs of more invasive options, such as dredging or dike construction and maintenance, both of which do significantly degrade habitat. Engineered logjams do not alter the gross appearance of the channel, aesthetically. They also create, rather than destroy, a good fish habitat feature, namely the presence of stable, large wood. Wood is a "fish magnet." Large wood is known to be an essential part of river fish habitat.

(Photo: engineered logjams on Elwha River, Washington)

There are other less-expensive versions as well, such as the “Seigyu” structures traditionally used in Japanese rivers. These are log pyramids weighted by bags of rocks.

(Photo: Seigyu, https://en.rattibha.com/thread/1640177574180708352)

These are designed to be easily rebuilt if they break up, and allow the option of placing more of them, or moving existing ones, as the river responds.

3. **Construct a "floodway" through the currently-flooded area.**
   This is a constructed channel, designed to carry a large portion of the floodwater through the flood-prone area during high flow without allowing it to spread out and impinge on infrastructure or houses. It would take the pressure off of the existing river channel during floods, at least in this reach.

   This action would need further study to know if it is feasible, but it has been applied in other areas. The floodway would need to be lined with bank armoring, possibly a low dike, and would need to be cleared of trees and other large vegetation. There would need to be an "entrance structure" where the floodway intersects the current river channel to control erosion at this point and allow water into the channel only when it reaches a certain flood level. The vicinity of this entry point would need to be dredged, locally. A natural place to build this might be along the current path of Battalion Creek. There is some evidence that Battalion Creek originally flowed straight from its canyon northeastward to enter the Stehekin River near the current road washout (RM 5.9), as its alluvial fan is just upstream from there. It could be returned to this entry point to accommodate the floodway.

Since this action does not influence sedimentation in the current river channel, it is not a complete long-term solution. It could, however, buy time for a more comprehensive approach to be designed and funded, while allowing the road and residences to coexist with the river. The river habitat would remain intact.

4. **Reach-scale dredging.**
   This would involve dredging from the point above the end of the Company Creek Road at least as far as the Company Creek alluvial fan.

   The consequences of this action would be to destabilize the river, forcing it to adjust to a new and artificial shape, streambed, and energy dissipation rate. The river would erode in places and deposit sediment in others as it seeks to reestablish a balance between its energy expenditure and its sediment load. Part of this adjustment would be reestablishing its coarsened streambed surface layer. Until that happens, there would be erosion of the bed, and transport of this sediment downstream beyond the dredged channel.

   Dredging on this scale would create a "knickpoint," that is, a short, steep zone of high energy dissipation and turbulence in the river channel that migrates upstream as it erodes the streambed. When the bed erodes, the height of the riverbanks increases, which destabilizes them. This destabilization spreads upstream, possibly for miles.

(Photo: Bridge pier undermined by migrating knickpoint from dredging)

Meanwhile, the dredged area begins to accumulate and store sediment again. As it fills with sediment, it starves the downstream channel of its sediment load. The "sediment-hungry" water then erodes the downstream channel. As the downstream bed erodes, it becomes destabilized, causing increased bank erosion and channel migration. This also can extend miles downstream.

A serious problem with this approach is that dredging inevitably involves removal of logjams and smaller accumulations of large wood in order to make room for the dredged channel and the heavy machinery doing the digging. This is very destructive to habitat, and exacerbates instability by removing a necessary structural element of the river channel. Wood slows the water current through the reach, concentrates hydraulic energy in local pools, and creates a "skeleton" that resists large-scale streambed and bank erosion. Removing large wood (logs, logjams) can initiate severe erosion of the streambed and streambank, causing channel incision (downcutting of the streambed). Moreover, the removal of logs and logjams causes severe habitat quality degradation, since large wood is such a well-documented necessity for good river habitat.

The sheer amount of streambed material that would need to be removed to dredge for flood control is staggering. The natural bankfull channel width (the water width when it just begins to flow onto the floodplain) in this area is over 200 feet, and the average bankfull depth 4 feet. Assuming a modest dredged channel only one quarter this wide (50 feet) with a modest depth of 3 feet though this reach would require moving about 60,000 cubic yards of material. That's 6,000 dump truck loads. The river's natural sediment load is high enough that the river could fill this in again in a good storm year.

Finally, periodic maintenance dredging would be necessary to maintain the channel depth. This implies that the dredged segment of the river will never be allowed to have logs or logjams, will never have roots or alcoves along its bank for fish habitat, nor will it have overhanging trees or shade. The habitat would be sacrificed in perpetuity.

5. **Constructing a much longer, stouter dike along the right bank from the location of the field dike all the way to the confluence of Battalion creek.**

There are numerous examples around the state where this has been done: parts of the Puyallup River, the lower Skagit River near Mount Vernon, parts of the Skokomish River and the Big Quilcene River, to name a few. Dikes of this caliber need to be cleared and maintained free of trees or other vegetation, since roots can compromise their strength. A consequence of this action would be that the river will continue to deposit sediment in the flood-prone reach, likely raising floodwater elevations inside the dike, or perhaps, move this sediment onward downstream where it will destabilize the next low-energy zone. This would eventually affect landowners on the other side of the valley, and create a demand for a similar dike over there. Eventually, even this large-caliber dike would likely fail and need to be rebuilt.

(Photo: dike repair at work along Skagit River, August, 2023. Source: goskagit.com)

Below is an impressive aerial photo of the Walla Walla River demonstrating how the river can break a dike in order to reestablish its natural configuration. Recall that straightened rivers are not stable.

Dikes give a false sense of security, causing people to forget that they live within reach of the river.

(Photo: Walla Walla River near Milton Freewater, Oregon, 1964 flood. Notice that the dike has failed in a way that re-established the natural meander pattern of the river.)


(Photo: Puyallup River after the 1996 flood. Red lines show dike failures.)

6. **Take measures to rebuild roads and protect homes while maintaining the wild character of the river.**

   This would include constructing road crossings over newly-activated channels, but generally allowing the river to migrate naturally. Houses that are vulnerable to flooding would need to be protected individually. Protecting an at-risk house individually could involve, for example, raising the house onto stilts, moving the house to higher ground (or out of a flood channel), or creating hardened structures to divert flow around the individual house to prevent local erosion.

Geological Hazards of the Stehekin Valley

As a final item to consider, the Stehekin Valley is exposed to some concerning potential hazards because of its mountain setting. It is a high-risk place to live. The threat of wildfire in the lower valley is very real. Also very real is the threat of fire on the mountain slopes upstream from the river mouth.

If fire were to occur here, comparable to the 2024 Pioneer Fire further down-lake, there would likely be landslides (debris flows) coming down into the lower valley in the following wet seasons. In addition to the obvious direct danger that this poses to life and property, it is possible that a big debris flow could dam the river itself during a flood event. Water would accumulate behind the dam until it suddenly broke through, sending a wall of water, woody debris and sediment down the valley. This would overwhelm any flood control effort in the areas known to be prone to flooding currently; only people living on higher ground would be safe.