FACT SHEET: DREDGING

Kentucky Division of Water

WHAT IS DREDGING?

Dredging is a deepening and straightening of a waterway, allowing water to move at a higher volume and speed. This effect increases the farther downstream you go and your waterway increases in size.

High water speeds lead to bank and bottom scouring, increasing erosion rates in streams. While erosion is a natural process, the increased flows and destabilization of the creek-bed by dredging may actually speed the process up and lead to significant property damage.

In the long-run this damage can be costly, and ultimately worsen the effects of flooding events.

IMPACTS OF DREDGING

- Destroys aquatic habitat critical for fish and other important aquatic organisms
- Leads to land loss from bank collapse and slumping
- Causes damage to critical infrastructure like roads, bridges, water, sewer, gas and electric lines
- Increases maintenance costs for structures clogged or damaged by debris dislodged in erosive events
- Siltation and suspension of nutrients and chemicals from the streambed may cause issues with drinking water sources leading to increased water treatment costs and higher water bills for consumers

Kondolf, M. G. 1994. Geomorphic and environmental effects of instream gravel mining. Landscape and Urban Planning 28 (1994) 225-243.

Kondolf, M. G. 1997. Profile: Hungry Water: Effects of Dams and Gravel Mining on River Channels. Environmental Management 21, 533-551.

ABSTRACT: Rivers transport sediment from eroding uplands to depositional areas near sea level. If the continuity of sediment transport is interrupted by dams or removal of sediment from the channel by gravel mining, the flow may become sediment-starved (hungry water) and prone to erode the channel bed and banks, producing channel incision (down-cutting), coarsening of bed material, and loss of spawning gravels for salmon and trout (as smaller gravels are transported without replacement from upstream). Gravel is artificially added to the River Rhine to prevent further incision and to many other rivers in attempts to restore spawning habitat. It is possible to pass incoming sediment through some small reservoirs, thereby maintaining the continuity of sediment transport through the system. Damming and mining have reduced sediment delivery from rivers to many coastal areas, leading to accelerated beach erosion. Sand and gravel are mined for construction aggregate from river channel and floodplains. In-channel mining commonly causes incision, which may propagate up- and downstream of the mine, undermining bridges, inducing channel instability, and lowering alluvial water tables. Floodplain gravel pits have the potential to become wildlife habitat upon reclamation, but may be captured by the active channel and thereby become instream pits. Management of sand and gravel in rivers must be done on a regional basis, restoring the continuity of sediment transport where possible and encouraging alternatives to river-derived aggregate sources.

The Center for Watershed Protection, Aquafor, Beech Limited, & Step by Step. (1999). Impact assessment of instream management practices on channel morphology, final draft report to the Vermont Geological Survey Agency of Natural Resources Department of Conservation. State of Vermont. https://dec.vermont.gov/sites/dec/files/geo/TechReports/VGTR2000-3ImpactAssessment.pdf

Ibisate, A., A. Ollero and E. Diaz. 2011. Influence of catchment processes on fluvial morphology and river habitats. Limnetica, 30(2): 169-182.

ABSTRACT: Fluvial morphology is conditioned by three basic elements: flow regime, sediment yield and valley characteristics. These elements are controlled by factors operating at different spatial and time scales, within and outside of the basin. Moreover, the great influence of human activities has to be considered as they presently constitute one of the main hydromorphological factors. This paper synthesises the effects of different variables on fluvial morphology and structures the review around the three basic elements mentioned above with examples from the Iberian Peninsula rivers. Understanding the factors that affect channel morphology is of primary importance for assessing river habitat condition, considering that river reach characteristics are the result of the interaction between upstream and downstream catchment and local conditions. Finally, fluvial geomorphology is a key element in river ecosystems that creates geodiversity and heterogeneity of fluvial forms at different spatial scales (i.e., river habitats) and should be considered part of our natural heritage and a valuable natural element itself.

Hawley, R. J., K. R. MacMannis and M. S. Wooten. 2013. Bed coarsening, riffle shortening, and channel enlargement in urbanizing watersheds, northern Kentucky, USA. Geomorphology 201, 111-126.

ABSTRACT: Stream systems naturally respond to watershed land use dynamics, particularly in urban developments with unmanaged impervious areas. Such urban-provoked alterations to channel morphology cause water quality impairments, have adverse effects on aquatic biota, and pose risks to adjacent public infrastructure. Over the past four years we have collected detailed hydrogeomorphic data at 40 unique stream locations throughout northern Kentucky, with at least two rounds of annually repeated surveys at 70% of the sites and three rounds of surveys at 50% of the sites. Analysis of this time-series data encompassed measured rates of instability across three distinct dimensions including (1) channel cross sections, (2) longitudinal profiles, and (3) bed material particle composition. Regression analyses between geomorphic change and 2011 watershed imperviousness indicated stream cross sections in urban/suburban watersheds tend to be getting larger— their overall shape is both deepening and widening. Additionally, stream riffle lengths are shrinking and their pools are becoming both longer and deeper; and finally, their bed material composition is coarsening, particularly in streams in the early stages of watershed development. By documenting fluvial geomorphologic dynamics in such detail, this study highlights the process by which unmitigated urbanization homogenizes stream habitat and degrades aquatic ecosystems. This improved, process-based understanding of the urban-induced channel response sequence has clear implications to both stormwater management and stream/ecosystem restoration, particularly in stream systems where headcut migration is a primary driver of channel instability.

DREDGING AND EROSION:
References and More Information

Hawley, R. J., K. R. MacMannis, M. S. Wooten, E. V. Fet and N. L. Korth. 2020. Suburban stream erosion rates in northern Kentucky exceed reference channels by an order of magnitude and follow predictable trajectories of channel evolution. Geomorphology 352, 106998.

ABSTRACT: This paper documents ranges of streambed and bank erosion observed across suburban northern Kentucky via time-series surveys at 61 stream monitoring sites from the last ~10 yr. Average erosion rates in streams draining undeveloped watersheds (<5% total impervious area, TIA) were nominal: 0.5 cm/yr of incision (range of −5.8 to 11 cm/yr) and 1.0 cm/yr of widening (range of −58 to 20 cm/yr). By contrast, streams draining developed watersheds (>5% TIA) averaged 1.5 cm/yr of incision (range of −9.2 to 36 cm/yr) and 9.4 cm/yr of widening (range of −11 to 61 cm/yr). The suburban streams also followed predictable patterns of evolution consistent with the “classic” Channel Evolution Model (CEM) of Schumm et al. (1984), with the initial incision period (Stage 2) coinciding with bed coarsening followed by widening (Stage 3). Out of 45 sites draining >5% TIA, only four were in a state of dynamic equilibrium (Stage 1), two of which were attributable to stabilization via stream restoration and another was attributable to an upstream stormwater retrofit that substantially restricted erosive discharges. The other stable suburban site drained a watershed that was only 6.5% TIA and was just upstream of a reach undergoing incision and headcutting, implying that it would likely be experiencing incision (Stage 2) soon. Although the suburban sites spanned a gradient of development age and extent, >90% fell into unstable CEM categories (Stages 2 through 4), with only one site exhibiting features emblematic of potential geomorphic recovery (Stage 4 trending to Stage 5), attributable to an upstream stormwater retrofit. This case study underscores the predictable nature of long-term channel instability in gravel/cobble streams draining conventionally-developed suburban watersheds in support of more mechanistically based stormwater management strategies tailored to prevent the geomorphic degradation commonly associated with the urban stream syndrome.

MORE RESOURCES: VIDEOS

In-channel Gravel Mining and Bar Pit Capture with Audio Narrative
https://www.youtube.com/watch?v=mDqpbwR_lLY
Demonstration of formation of headcuts, incision, terrace formation and more. This clip has an audio narrative by Steve Gough.

Flood vs Steady Side by Side
https://www.youtube.com/watch?v=7StgdcPwzms
Shows side-by-side contrast of how differently the landscape is changed by two flow regimes. The bar graphs chart the volume of water that has flowed through our 4-meter Emriver model (Em4).

Channelization, Large Meanders, Packed Sediment
https://www.youtube.com/watch?v=NG9_DJm8LFg
This is a time-lapsed Emriver channelization demonstration in which a meander loop is cut off. In this case the channel length between two points is more than halved, so slope would increase by a factor of 2+. The playback speed varies and is noted on the video. Note the relative stability of the system before channelization, in which a small amount of sediment is moving through the reach, but there is little bank erosion and by one definition—sediment in = sediment out—the system is very stable. A moving circle and the words “uniform bedload transport” illustrate this. After the channelization note bank failures both up and downstream, and that the channel slowly reestablishes a meandering form so that its overall length is about the same as before the channelization. Graphics show how bedload transport greatly increases due to incision and bank erosion upstream of and within the reach. During the remeandering process, note that there is a net export of sediment— you can see this by visually comparing sediment movement into the reach versus that out of it. Near the end of the clip (2:17), transect graphics appear. These show the wide, unstable nature of the channelized reach versus the narrow, more stable upstream reach.

MORE RESOURCES: VIDEOS

Unintended Effects of Dredging
https://www.youtube.com/watch?v=OAZ_BuyM41s
Nature abhors a vacuum and removing accumulated material from a river channel can have far-reaching and unintended consequences. The first principle effect is to increase the demand for eroded river-bed and river-bank material from upstream. This can dramatically increase the rate of erosion in upstream reaches. The second major effect is the interruption of the transport of sediment downstream of the dredged reach. Whilst the bed material is being re-accumulated in the dredged area, there is far less material being supplied downstream. That "cutting off" of the sediment supply causes a net increase in the erosion downstream of the dredged reach as well. This is due to stopping the supply of material that would otherwise "patch up" and fill in eroded areas to produce a more stable dynamic equilibrium state.