The Water Center ◆ Fact Sheet January 2004

Down Under:
Hyporheic zones and their function

Definitions

The hyporheic zone is the region beneath and adjacent to streams and rivers where surface and ground water mix. Hyporheic flows occur across multiple scales including: salmon redds (spawning nests), pool-riffle sequences, gravel bars, and beneath riparian terraces. Wherever there are permeable sediments, a hyporheic zone will exist. Zone delineations* are driven by the researcher's question and are based on biological, biogeochemical, and/or physical parameters. Accepted definitions include:

- Saturated sediment beneath and alongside streams and rivers containing both groundwater and surface water.
- Subsurface water containing a minimum of 10% surface water.
- Subsurface zone in which organisms, termed the hyporheos, are adapted to interstitial conditions.

Fundamental characteristics

The physical conditions required for a hyporheic zone include permeable sediments and differences in pressure head (height of water resulting from surrounding geology and atmospheric pressure) between subsurface and surface water. More porous and permeable sediments, which create higher rates of hydraulic conductivity (the rate of water traveling through the sediment), result in greater potential for interchange between surface and subsurface water. Changes in pressure head throughout the stream and riparian zone create upwellings of subsurface water into the stream and downwellings of stream water into the hyporheic zone.

The size of a hyporheic zone can range from centimeters wide and deep to several kilometers, depending on geology and channel morphology. Water can remain in the hyporheic zone from minutes to months, depending on the flowpath's length and sediment hydraulic conductivity. Lateral distribution of the hyporheic zone into riparian areas or across floodplains is greatly influenced by paleochannels, which are subsurface flowpaths where hydraulic conductivity is greater than the surrounding sediments. Paleochannels can carry hyporheic water hundreds of meters away from the stream.

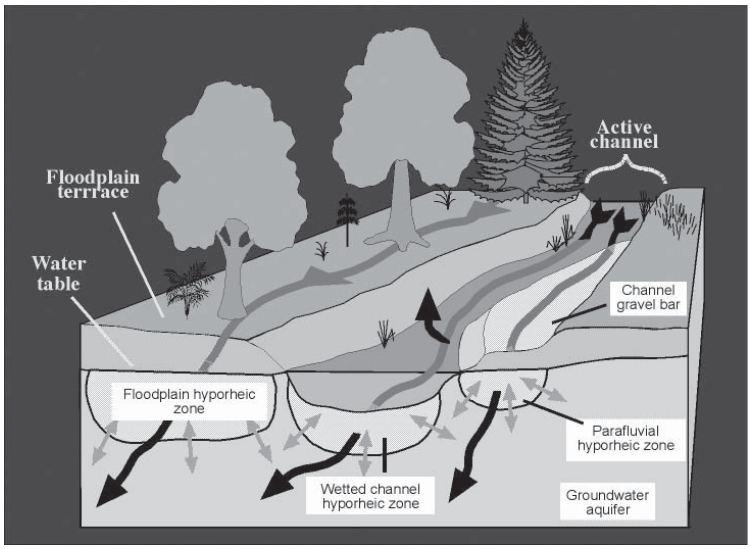

Figure 1 depicts the complexity of subsurface flow and outlines the various hyporheic habitats that exist in stream and river ecosystems. Image modified from Edwards 1998.

Functions

Hyporheic zones link aquatic and terrestrial systems and serve as transition areas between surface water and groundwater systems. The hyporheic zone contains species common to both surface and subsurface systems and maintains gradients of nutrient cycling and energy flow.

- **Nutrient cycling** Streams with intact hyporheic zones provide more temporary storage space and residence time for water than streams without hyporheic zones. As a result, nutrients and other materials remain in the system longer before they are lost downstream. Bacteria, fungi, and protozoa (epilithon) that live on sediments convert nutrients into food, making the hyporheic zone an area of high productivity. Because hyporheic water has greater exposure,

both in residence time and physical extent, to these sediments than surface water, biogeochemical process rates are increased. The inorganic nutrients that are transformed along hyporheic flowpaths are then redelivered to the stream water where they stimulate algal growth. Furthermore, the hyporheic zone supplements the nutrients that algae need to recover from floods and other disturbances. Marine-derived nutrients from dying and dead salmon can also be transported by hyporheic flows, which can result in higher growth rates for riparian vegetation.

- **Habitat** Hyporheic zones harbor a diverse community of invertebrates including microcrustaceans, oligochaetes, water mites, and early larval forms of stonefiles and mayflies—up to 80 invertebrate species have been recorded from a hyporheic zone in a single sampling location. In some systems, the emergence of aquatic insects from the hyporheic zone is an important food source for fish. The hyporheic zone is also prime habitat for spawning salmon, since oxygenated stream water downwelling through redds creates an environment ideal for egg development.
- **Temperature** Moderation of stream temperature can occur through subsurface-surface water exchange, helping to reduce summer peak temperatures and increase winter low temperatures.
- **Contaminant Removal** As hyporheic water flows from the riparian zone to the stream, the riparian area may retain nutrients. In the case of a riparian zone with high rates of denitrification (conversion of dissolved nitrate to nitrogen gas), retention of nutrients may result in less nitrogen reaching the stream. The hyporheic zone can also trap heavy metals and other contaminants that absorb to sediments, thus improving surface water quality.

Management implications

Hyporheic zones are dynamic hydrologic ecotones critical for maintaining the health of many river systems. Agriculture, forestry, and urbanization may have detrimental effects on hyporheic zones and the processes that occur there, including altering their extent, distribution, and ability to provide nutrient cycling, habitat, temperatures, and contaminant removal functions. Land-use activities also have the potential to alter oxygen levels and biogeochemical processes occurring within the hyporheic zone, thereby negatively affecting water quality, stream productivity, habitat quality, and biodiversity. These effects to hyporheic systems are mediated by changes to stream sediment inputs, large woody debris inputs, channel geometry, and hydrology. Greater consideration of the role and functioning of hyporheic zones when making management decisions will result in more productive and sustainable river systems.

Further reading

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Triska, F.J., V.C. Kennedy, R.J. Avanzino, G.W. Zellweger, and K.E. Bencala. 1989. Retention and transport of nutrients in a third-order stream: Channel processes. Ecology 70:1877-1892.

* See The Water Center's Fact Sheet *Delineation of the Hyporheic Zone* for information on delineation and sampling of hyporheic zones.

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