Stream Power in Irish Rivers

The three main processes of a fluvial system are erosion, transport and deposition. These processes of the river system continually reshape the landscape over which the river flow. The ability of a river to erode, transport and deposit sediment load, depends upon the various factors such as the water volume, water velocity, gradient, sediment size, channel width, and depth. Each of these factors influences the river's energy. Generally large and fast-flowing rivers have more energy. The flow of a river is affected by the channel gradient, the depth of the water and the width of the river channel. The more energy the river has, the more capable of eroding and transporting sediment load. Stream power measures the river's energy using a mathematical equation. Stream power is represented by the Greek capital letter omega (Ω). It is essentially the product of the water surface slope (S), water density (p), water discharge (Q) and gravity (g). Specific stream power is more effective when it comes to comparing different rivers and reaches. It is represented by (ω) (Charlton, 2008).

Stream power has a direct relationship with sediment transport. Stream power determines the capacity of a given flow to transport sediment at a given time. It is a measure of the main driving forces acting in a channel and determines a river's capacity to transport sediment and perform geomorphic work…… Power stream is measured in watts(W) per unit length of stream channel (W m-1). (Charlton, 2008). Water flowing in a river can dramatically change the surrounding landscape over the course of the years. Therefore, understanding of sediment transport and channel sensitivity to erosion or deposition processes is essential for river management. The calculation of stream power can be a useful predictor of boundary erosion, channel migration, sediment transport and deposition, and river's bedform type. Largely, these determine the geomorphology of the channel and floodplain. It also helps to understand which areas along rivers are susceptible to erosion hazards and sedimentation. Sediment transport also modulates the natural functions of rivers of shaping landscapes and creating riparian habitat (Charlton, 2008). This essay will look at the data of stream power and specific stream power across the Irish rivers. It will then discuss that how the why stream power varies based on spatial locations and the equation calculation methodology.

Stream power is defined by quantitative equations that predict the total sediment concentration. It is calculated by multiplying density of water, gravitational constant, water surface slope, and water discharge. $\Omega = \rho g Q S$, where Ω is stream power, ρ is the density of water, g is gravity, Q is river discharge, and S is the channel slope. The two variables are constant the water density weigh, p = (1,000 kg/m3) and the gravitational constant, g = (9.8 m/s2). Channel slope is difference in channel bed elevation along a given length of channel divided by that length in meters. The Discharge is the volume of water passing through a given channel cross-section in a given time. It is one of the main factors of erosion. It is measured in cubic meters per second (m3/s-1). Water discharge Q = WDV, where, W is width, D is depth, and V is velocity (Knighton, 1998).

Say, channel slope S, is 0.00146m and Q, is 104.528 (m^3/s)

Stream power (Ω) = $\rho g Q S$

(Ω) = 1000 (kg/m^{-3}) x 9.8 (m/s^{-2}) x 0.00146 (m) x 104.528 ($^{m3}/s$)

(Ω) = 1498.138 (w/m^{-1})

The Specific stream power (ω) is calculated by dividing the stream power per meter length of channel by the mean width of the channel. This is useful for making comparisons between rivers or different reaches of same river, since it reduces the scale effects of rivers.

Specific stream power (ω) = Ω/W where, W is the width

Say, width 1 = 35.24 m

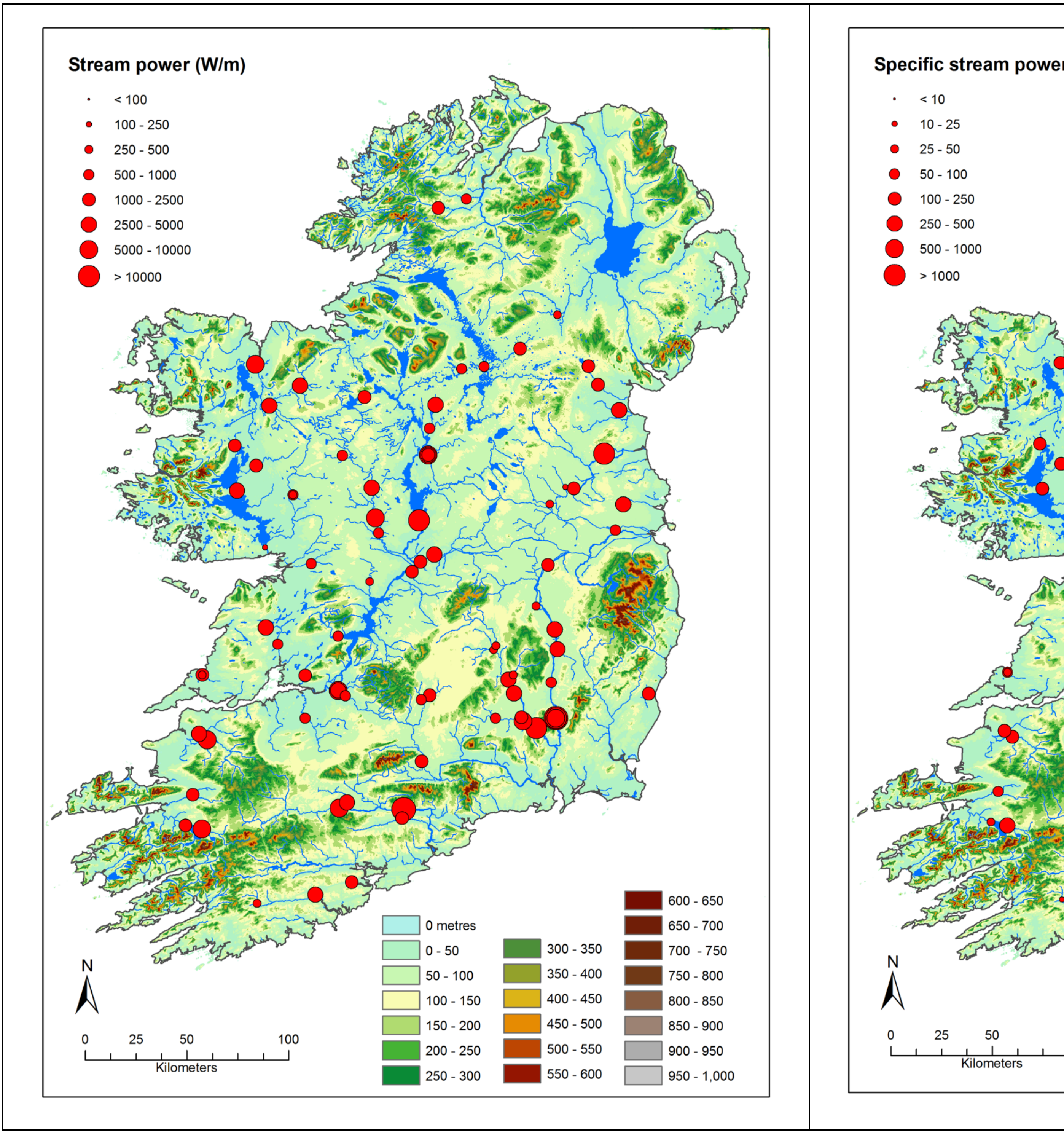
Width 2 = 31.28 m

Width 3 = 28.31 m

The mean width is 31.61 m.

Specific stream power (ω)= 47.39 (w/m^{-2})

The following maps of specific stream power and specific stream power are produced by using the same above methods. These maps of Ireland show the spatial pattern of the stream power and specific stream power data as proportional circles. The first map shows the pattern of stream power and the second map shows the pattern of specific stream power in rivers in Ireland. The units of stream power is measured in (W/m) and the specific stream power is measured in (W/m^2). The size of circles represent the level of energy. These data are remotely sensed data, collected by using Google Earth 3-d geospatial viewer on the internet.



Source: https://brightspace.ucd.ie/d2l/le/content/55264/viewContent/710078/View

In the maps, the small circles indicate the low energy and big circles indicate the higher energy of specific power in the Irish rivers. The specific stream power is proportionally smaller than the specific stream power since it reduces the scale effects of rivers. In a typical stream system, there is relatively lower power and greater sediment supply near the headwaters, high stream power in the middle transport reaches, and deposition on the broad and flat floodplains (Charlton, 2008). As we can see that stream power is higher in the middle zone area of the rivers which is the sediment transfer zone of rivers. The middle zone area of rivers has more water because of the tributaries join. It also shows that the major rivers such as the river Shannon, the river Barrow, Blackwater, and the river Boyne have higher energy. It could be the fact that the bigger rivers tend to have bigger drainage basins and the longer course, therefore, more tributaries network that increases the water flow downstream. There are more gauging stations and relatively close to one another in the river Barrow and the Nore, where the elevation also high. It shows that the river Barrow and the Nore have the relatively the same amount of stream power energy this could be the similarity in channel gradient.

There is a variation of stream power within a river. For instance, the longest river in Ireland the river Shannon has a very different pattern of its energy along its reach. It has fairly low energy in comparison to its size and length. The reason could be the river Shannon has a larger parameter and it results in a lower hydraulic radius because the loss of energy arises from friction with the bed and banks will be greater for the wider width channel. The other reason could be the low gradient and organic mats, vegetation riparian system. However, there is high energy at the mouth of the lake Ree, this could that the river width is narrower at the mouth of the lake and steeper channel slope because of an incision. The valley slope is also significant, affecting the steepness of the channel which, together with discharge determines stream power. The river systems are open systems, it means energy and materials are exchanged with the surrounding environment (Charlton, 2008). Therefore energy fluctuates within a river channel. The water discharge usually increases with the size of the upstream drainage area. Also, discharge increases downstream as the area of the drainage increases and tributaries join the main channel. This shows in the River Boyne that it has comparably bigger drainage basin, therefore, stream power is higher there.

If the stream is exactly sufficient to transport the sediment load there will a balance between erosion and deposition. If there is an increase in the volume or caliber of the sediment load in relation to the available stream power it will results in sediment deposition within the channel. In this case, aggradation will occur along the river reach. If the stream power exceeds what is needed to transport the sediment load it causes to entrain sediment from the bed and erode the channel boundary and degradation will become predominant. Aggradation can be influenced by upstream channel erosion and human activities such as mining and agriculture. Whereas, degradation can be caused by a decrease in sediment supply or an increase in flood frequency and also if the bed sediment is too coarser to be moved by the stream power. Moreover, It can also occur downstream from dams and where gravels and sediments are removed from the river bed for mining (Charlton, 2008). However, the stream power equation lakes in telling that where within the reach erosion will occur. Therefore, this equation is not useful for predicting the actual nature of channel change. Stream power characterizes the driving force available for sediment transport. However, it does not characterize all of the elements that affect the physics of moving sediment, for example, grain sheltering and imbrication, roughness from sediment particles and bedforms, lift forces from turbulence, lift forces from pressure gradients, and organic mats (Knighton, 1998). Stream power and specific stream power do not account for resisting forces in sediment transport. Such as the weight of sediment, vegetation that dissipates flow energy, roots that hold sediment, and cohesiveness of bed material.

The ability of a stream to erode material from its bed and banks or deposit material is ultimately controlled by other variables such as stream discharge, slope of the bed, gravity and sediment supply balanced by the resistance of the bed and bank materials. The flow of water in the river provides the energy required to shape the channel and the characteristics of that flow are essential in determining channel form. The process of sediment transport is very different for coarse and fine sediment. The finer materials such as clay particles, sands and silts are carried in the flow as suspended load. This can be transported over considerable distances since little energy is required to move small particles like sand grains. Course sediment weights more are transported close to the channel bed as bedload. The form and behavior of bedload-dominated channels are different from suspended load dominated channels. Flow velocity varies over both space and time in natural channels. It is determined by the channel slope, roughness and cross-section form.

Reference

Charlton, R. (2008) *Flow In Channels*, FUNDAMENTALS OF FLUVIAL GEOMORPHOLOGY

Charlton, R. (2008) *The Fluvial System,* FUNDAMENTALS OF FLUVIAL GEOMORPHOLOGY

Charlton, R. (2008) *Processes of Erosion, Transport and Deposition,* FUNDAMENTALS OF FLUVIAL GEOMORPHOLOGY

Knighton, D. (1998) *Fluvial process,* FLUVIAL FORMS AND A New Perspective, Hodder Education an Hachette Company UK

Knighton, D. (1998) *Drainage network* , FLUVIAL FORMS AND A New Perspective, Hodder Education an Hachette Company UK

Knighton, D. (1998) *Catchment Processes*, FLUVIAL FORMS AND A New Perspective, Hodder Education an Hachette Company UK