1. a) The peak of the salt pulse travels at the mean velocity of the stream. It looks like peak arrives 20 m downstream (the sampling point) after about 750 s.

\[ V = \frac{20 \text{ m}}{750 \text{ s}} = 0.027 \text{ m/s} = 2.7 \text{ cm/s} \] (a rather sluggish stream)

b) The curve is NOT expected to be exactly Gaussian because this time-series data rather than the spatial distribution. The cloud of salt continues to expand as it passes the sampling point so the part that arrives first will rise more quickly than the corresponding drop-off in the tail end of the cloud, which will appear to recede more gradually. However, since the skewness in the time distribution is not great here, we can assume the cloud is “frozen” as it passes and convert the \( C \) vs. \( t \) data to \( C \) vs. \( x \) data.

We want to get \( \sigma \), which occurs at 0.61 times the peak \( C \), which looks like 4600 micromhos.

\[ 0.61(4600) = 2800 \text{ micromhos} \]

Width of the distribution at the 2800 levels is about 500 s = 2 \( \sigma \), so \( \sigma = 250 \text{ s} \). Convert time interval to the width of the cloud by using the velocity. \( \sigma = (250 \text{ s})(0.027 \text{ m/s}) = 6.75 \text{ m} \)

\[ D = \frac{\sigma^2}{2t} = \frac{(6.75 \text{ m})^2}{2(750 \text{ s})} = 0.030 \text{ m}^2/\text{s} = 300 \text{ cm}^2/\text{s} \]

Notice this is over 10,000,000 time larger than molecular diffusion, even in this sluggish stream.

2. a) Minimum flux would be purely molecular diffusion

\[ J = -D \frac{\partial C}{\partial z} \], where \( D = 1 \times 10^{-9} \text{ m}^2/\text{s} \) and the vertical conc gradient is estimated from

Figure 2-7: DO drops from about 8 mg/L to zero in what looks to me like about 2 m, so:

\[ J = -\left(1 \times 10^{-9} \text{ m}^2/\text{s}\right)\left(\frac{8 \text{ mg}}{2 \text{ m}}\right)\left(\frac{1 \text{ L}}{10^{-3} \text{ m}^3}\right) = 4 \times 10^{-6} \text{ mg/s} - \text{ m}^2 = 4.0 \text{ mg/s - m}^2 \]

or about 0.35 mg/day-m². To put that in perspective, imagine a layer of water just below the thermocline that is 1 cm thick. One square meter of such a layer would contain 10,000 cm³ or 10 L of water. According to the above calculation, these 10 liters would receive only 0.035 mg of oxygen per day, or 0.035 mg/L per day. (By comparison the surface water has about 9 mg? Of DO). It’s easy to see how microbial respiration in the hypolimnion rapidly depletes the DO because the supply of fresh DO is so slow.
b) Actual flux is probably greater than this because the thermocline zone in reality is not 100% stagnant and there will always me a small amount of mechanical mixing across it. (For example if a fish swims through it or a boat propeller disturbs it).

c) DO transport is not enough to keep up with respiration in the hypolimnion, as discussed above.

3. (9) Dribbling TCA at 10 mg/min into a stream with discharge of 10 L/min.

a) If the TCA totally dissolves then the maximum concentration is

\[
\frac{10 \text{mg/min}}{10 \text{L/min}} = 1 \frac{\text{mg}}{\text{L}}
\]

This much less than solubility of TCA, so it is achievable.

b) At equilibrium, all of the TCA will dissolve because 1 mg/L is much less than the solubility limit. However, if the rate of dissolution is very slow, it is possible in such a shallow stream that dense TCA liquid droplets could settle to the bottom and form a small layer of DNAPL (dense non-aqueous phase liquid) which is not in equilibrium. However, I suspect that is pretty unlikely if the input is a mere 10 mg/min into a 10 L volume.