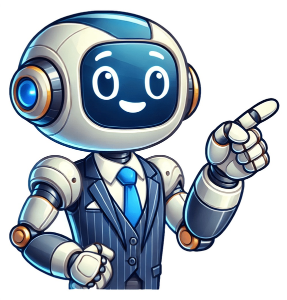

There are many human activities which change the river landscapeThis impacts on the storm hydrograph, changing thelag timeand dischargeHuman Factors Affecting Storm HydrographsHuman FactorsImpactEffect on HydrographDeforestationLack of trees reduces interception and infiltration, increasing overland flowAfforestationAn increased amount of trees increases interception and infiltration reducing overland flowRiver managementDams can be used to control the level of discharge downstreamUrbanisationImpermeable concrete and tarmac increase overland flowWater flows into the drains reaching the river rapidlyAgricultureBare soil and ploughing increase overland flow, especially where ploughing is downslopeReplacement of pasture (grassland) with arable crops also increases overland flowClimate changeRising global temperatures may increase storm frequency and intensity, increasing precipitationIncreasing drought which leads to baked soil and periods of extreme cold which freeze the soil which means that water cannot infiltrateDeforestation, urbanisation and agriculture all increase the overland flowOverland flow reaches the river more rapidly than through flow or groundwater flowThis means that the lag time is reducedThey also increase the amount of water which reaches the riverThis increases the level of discharge leading to a steep rising limbThe combination of these factors leads to a storm hydrograph which has a rapid response to a rainfall or storm eventAfforestation increases the time the lag time and increases infiltration so less water will reach the riverImage showing comparison between urban and rural hydrographyExplain two ways in which human activities can affect storm hydrographs(4 marks)You will not be awarded marks if you make a point and then for the second part write the opposite. For example, you might refer to deforestation increasing discharge and decreasing the lag time. If you then write about afforestation decreasing discharge and increasing the lag time, you will only be awarded 2 marksAnswerMore urbanisation (1) increases rates of run-off (or equivalent idea e.g. reduces infiltration) and/or more water in the river/higher discharge (1)Changing agricultural practices/ land use (1) such as ploughing land previously left in grass which will increase runoff (1)Deforestation/Afforestation (1) affects interception and infiltration rates so changing run-off and thus lag-times (1)Climate change my increase/decrease storminess (1) which will affect lag-times because of changes in infiltration/run off relationships (1)Human management of rivers e.g. levees (1) maintains more water in the channel (1)In 4 mark answers take care to not simply write the opposite for the second set of two marks. If you do this you are not showing the breadth of knowledge expected and will only be awarded marks for the first part of your answer. See the above worked example which illustrates where this could happen.York is a city located in the north of EnglandThe city's population is just over 200,000York regularly floods: Serious flooding has occurred in 1947, 1978, 1991, 1995, 2000 and 2015The floods in 2000 were the worst on recordThe Ouse rose almost 5.4 meters above its normal level540 properties were flooded and 320 were at serious risk18,700 hectares of farmland were affectedThe overall cost of the floods was estimated to be over 12 million including lost income from tourismPhysical and Human Causes of 2015 FloodPhysical CausesHuman CausesBefore reaching York the Ouse is joined by a number of large tributaries (Swale, Ure and Nidd) which flow from the Yorkshire DalesFarming in the Vale of York and grazing in the Yorkshire Dales means interception is reduced due to decreased tree cover and lack of other vegetationAnnual precipitation levels in the Yorkshire Dales are between 600-1000mm. In 2010 one month's rain fell in just 24 hoursIncreased urbanisation around the city with new housing developments, retail parks and industrial areas have increased impermeable surfacesYorkshire Dales are upland areas with steep slopesErosion of peat in upland areas reduces the amount of moisture held in the soilLand around York is low-lying and flatFailure of the Foss Barrier increased flooding in the east of the cityYork lies on the confluence of the riversFoss and OuseDeforestation in upland areasDid this page help you?Hydrographs can be of different shapes. The characteristics of a river, its drainage basin and the amount of water entering the system affect the shape of a flood hydrograph.A gentle hydrograph shows the river is at low risk of flooding. These types of hydrographs have a gentle rising limb and a long lag time, which means it takes longer for the peak rainfall to reach the river channel, so the river discharge is increasing slowly.A gentle hydrographFlashy hydrographs have a steep rising limb and a small lag time. This indicates that river discharge increases rapidly over a short period, indicating rainwater reaches the river very quickly. This means the river is more likely to flood.A flashy hydrographRural areas with predominantly permeable rock increase infiltration and decrease surface runoff. This increases lag time. The peak discharge is also lower as it takes water longer to reach the river channel.Physical Factors Affecting Storm HydrographsA range of physical factors affect the shape of a storm hydrograph. These include:Large drainage basins catch more precipitation and have a higher peak discharge than smaller basins. Smaller basins generally have shorter lag times because precipitation does not have as far to travel. The shape of the drainage basin also affects runoff and discharge. Drainage basins that are more circular in shape lead to shorter lag times and a higher peak discharge than long and thin ones because water has a shorter distance to travel to reach a river.Drainage basins with steep sides tend to have shorter lag times than shallower basins. This is because water flows faster on the steep slopes down to the river.Basins with many streams (high drainage density) drain more quickly and have a shorter lag time.If the drainage basin is already saturated, surface runoff increases due to the reduction in infiltration. Rainwater enters the river quicker, reducing lag times, as surface runoff is faster than baseflow or through flow.If the rock type within the river basin is impermeable, surface runoff will be higher, and throughflow and infiltration will also be reduced, meaning a reduction in lag time and an increase in peak discharge.If a drainage basin has a significant amount of vegetation, this will have a significant effect on a storm hydrograph. Vegetation intercepts precipitation and slows the movement of water into river channels. This increases lag time. Water is also lost due to evaporation and transpiration from the vegetation. This reduces the peak discharge of a river.The amount of precipitation can affect the storm hydrograph. Heavy storms result in more water entering the drainage basin, resulting in a higher discharge. The type of precipitation can also have an impact. The lag time is likely greater if the precipitation is snow rather than rain. This is because snow melts before the water enters the river channel. When snow melts rapidly, the peak discharge could be high.Human Factors Affecting Storm HydrographsA range of human factors affect the shape of a storm hydrograph. These include:Drainage systems that humans have created lead to a short lag time and high peak discharge as water cannot evaporate or infiltrate into the soil.Areas that have been urbanised result in increased use of impermeable building materials. This means infiltration levels decrease and surface runoff increases. This leads to a short lag time and an increase in peak discharge.Key TermsHydrograph a graph that shows river discharge and rainfall over time.Flood when the capacity of a river to transport water is exceeded, and water flows over its banks.Base flow The base flow of the river represents the normal day-to-day discharge of the river and is the consequence of groundwater seeping into the river channel.Storm flow storm runoff resulting from storm precipitation involving surface and through flow.Bankful discharge the maximum discharge that a particular river channel can carry without flooding.Peak discharge the point on a flood hydrograph when river discharge is at its greatest.Peak rainfall the point on a flood hydrograph when rainfall is at its greatest.Lag time the period between the peak rainfall and peak discharge. Back to Library Comparing Two Hydrographs Steeper hydrographs mean more likely to be a storm event or urban area. The lag time is shorter in these storm hydrographs. Discharge of River There are a range of physical factors that affect the shape of a storm hydrograph. These include: Large drainage basins catch more precipitation so have a higher peak discharge compared to smaller basins. Smaller basins generally have shorter lag times because precipitation does not have as far to travel. The shape of the drainage basin also affects runoff and discharge. Drainage basins that are more circular in shape lead to shorter lag times and a higher peak discharge than those that are long and thin because water has a shorter distance to travel to reach a river. Drainage basins with steep sides tend to have shorter lag times than shallower basins. This is because water flows more quickly on the steep slopes down to the river. Basins that have many streams (high drainage density) drain more quickly so have a shorter lag time. If the drainage basin is already saturated then surface runoff increases due to the reduction in infiltration. Rainwater enters the river quicker, reducing lag times, as surface runoff is faster than baseflow or through flow. If the rock type within the river basin is impermeable surface runoff will be higher, throughflow and infiltration will also be reduced meaning a reduction in lag time and an increase in peak discharge. If a drainage basin has a significant amount of vegetation this will have a significant affect on a storm hydrograph. Vegetation intercepts precipitation and slows the movement of water into river channels. This increases lag time. Water is also lost due to evaporation and transpiration from the vegetation. This reduces the peak discharge of a river. The amount precipitation can have an affect on the storm hydrograph. Heavy storms result in more water entering the drainage basin which results in a higher discharge. The type of precipitation can also have an impact. The lag time is likely to be greater if the precipitation is snow rather than rain. This is because snow takes time to melt before the water enters the river channel. When there is rapid melting of snow the peak discharge could be high. Human Factors Affecting Storm Hydrographs There are a range of human factors that affect the shape of a storm hydrograph. These include: Drainage systems that have been created by humans lead to a short lag time and high peak discharge as water cannot evaporate or infiltrate into the soil. Area that have been urbanised result in an in crease in the use of impermeable building materials. This means infiltration levels decrease and surface runoff increases. This leads to a short lag time and an increase in peak discharge. Lag Time What is a hydrograph? Your answer should include: River / Water / Discharge / Flood What impacts on a rivers' discharge? Your answer should include: Urbanisation / Discharge / Tributaries / Confluences / High / Drainage / Density / Vegetation Explain how a short lag time is created. Your answer should include: High / Discharge / Urban / Area / Quick / Fast In this article we will discuss about:- 1. Meaning of Runoff Hydrograph 2. Components of Hydrograph 3. Factors Affecting the Shape 4. Base Flow Separation.Meaning of Runoff Hydrograph: Hydrograph is a graphical or tabular presentation of instantaneous runoff/discharge rate against time. Sometimes, it is also known as storm hydrograph, flood hydrograph or simply hydrograph. A hydrograph presents the total runoff (direct + base flow) occurring at a given time. It also shows the distribution of total runoff with respect to time at a certain point of measurement. All hydrographs have three characteristics regions viz.,- rising limb, crest segment or peak point and falling limb. These characteristics regions are shown in the schematic diagram of the hydrograph (Fig. 2.6). The hydrographs are mainly in two types, i.e., single peaked and multi-peaked. The multi-peaked hydrograph is also known as complex hydrograph. The occurrence of single or multi-peaked hydrograph depends on rainfall characteristics, complexity of watersheds and their peculiar interactions. For example an isolated rainfall yields the single peaked hydrograph, while complex storm (varying rainfall intensity) yields the complex hydrograph. Components of Hydrograph: 1. Rising Limb:It is also known as concentration curve, is the ascending portion of hydrograph. Its slope steepness depends on the rise of discharge due to gradual building of storage in drainage channels as well as over the watershed surface. The shape of rising limb is dependent on the storm and watershed characteristics, both. In general, the shape of rising limb is being concave upwards and rises slowly in the early stage of the flow, but as the storm continues and more and more flow from distant apart reaches to the outlet of watershed, the rising limb rises very rapidly up to the peak point of the hydrograph. The time base of hydrograph is fixed by the duration of outflow. In a simple hydrograph, the extent of rising limb is comparatively shorter than the falling limb, as a result the area below this limb is less to that of the falling limb. 2. Crest Segment:This segment is one of the very important parts of the hydrograph, as it contains the peak flow. It is extended from the point of inflection on the rising limb to a similar inflection point on the falling limb. The peak flow occurs, when various parts of the watershed yield the runoff simultaneously to the outlet. Generally, in large watersheds the peak flow occurs, when rainfall gets stop. The time interval from centre of mass of rainfall to the peak is controlled by the storm and watershed characteristics. Hydrographs of some watersheds resulted from a single and relatively short duration rainfall, have two or more peaks. Multi-peak, i.e. complex hydrographs can also occur, when two or more storms occur in a close succession. 3. Falling Limb:It is the descending portion of hydrograph, is also known as recession limb. The falling limb is extended from the point of inflection at the end of crest segment to the commencement of natural ground water flow. It represents the withdrawal of water from the storage build up in the watershed during initial phase of hydrograph. The point of inflection on the falling limb of the hydrograph indicates the stage, when rainfall has been stopped and channel flow is due to storage made over the watershed. The shape of falling limb is dependent only on the physical features of the channel; and is independent of the storm characteristics. Generally, falling limb is in convex shape due to continuous decrease in runoff volume. Variation in areal rainfall distribution minutely affects the shape of recession curve. Unusually high rainfall intensity results the rapid recession, while delayed recession is due to concentration of rainfall in upper portion of the basin. Factors Affecting the Shape of Hydrograph: The shape of hydrograph is dependent on the runoff volume and time to peak of the watershed. Various factors that affect the shape of hydrograph can be broadly grouped into following two groups: 1. Climatic factors; and 2. Physiographic factors. Each of the two groups of factors, affecting the shape of hydrograph, further contain host of the factors; the important ones are listed below:1. Climatic Factors:These are mainly the storm characteristics, given as: i. Types of precipitation ii. Intensity of rainfall iii. Duration of rainfall iv. Direction of rainfall v. Magnitude of rainfall vi. Other factors, like initial losses and evapotranspiration. 2. Physiographic Factors:Include the basin as well as channel characteristics, are given as under: Basin characteristics: i. Shape ii. Size iii. Slope iv. Nature of the valley v. Elevation vi. Land use pattern; and vii. Soil characteristics of the basin. Channel Characteristics: i. Cross-section of the channel ii. Roughness of the channel iii. Storage capacity, and iv. Drainage density etc. Generally, the climatic and physiographic factors control the rising limb and peak segments, while recession limb is only by the physiographic factors. The time base of hydrograph is mainly influenced by the watershed characteristics i.e., physiographic factors. Base Flow Separation from Hydrograph: A runoff hydrograph represents the cumulative runoff resulted from surface and sub-surface (base flow) runoff. The surface runoff or direct runoff hydrograph is obtained from the total storm hydrograph by separating the base flow. The separation of base flow is an arbitrary manner, unless a large flow from the antecedent storm is available. Due to this reason the errors made in the base flow separation are taken as negligible. A simple hydrograph, which is not affected by the rainfall, prior to or subsequent to the period of observation, any one among following three methods, can be used:1. Straight Line Method:This method consists of drawing a straight line from the beginning of the surface runoff to an arbitrary point on the recession limb, representing the end of the direct runoff. In Fig. 2.7, it is shown by the line a. b, in which point a represents the beginning of direct runoff, is identified by the view of sharp change in the runoff rate. The arbitrary point b is roughly located at the time N = 0.84 A0.2 days after the peak of the hydrograph, in which A is the watershed area (km2) and N is in days. The accuracy of N depends on careful study of a number of isolated storm hydrographs. This method of base flow separation is the simplest among all three methods. 2. Method-II:In this method the base flow curve existing prior to the commencement of surface runoff, is extended till it intersects the straight line drawn from the peak of the hydrograph. This point is joined to the arbitrary point (b), simply by a straight line. In Fig. 2.7, it is shown by straight line ac and cb. The area below this line of hydrograph represents the base flow, while the area above the line is noted as direct runoff. This method is most suitable and widely used for base flow separation. 3. Method-III:This method is based on the use of composite base flow recession curve. In this method, the base flow recession curve, after depletion of the flood water is extended backward till it intersects the straight line, drawn from the point of inflection. In Fig. 2.7, it is shown by joining the point a to point f and point f to b by smooth curve. This method is appropriate, particularly when ground water contribution is expected to be significant and reaches the stream, quickly. We're fetching your file...Please wait a moment while we retrieve your file from its home on the internet An alternate approach is presented where graphing discharge can be accomplished without a time axis. This technique allows data properties such as Q, dQ/dt, and d2Q/dt2, and trends of increasing, decreasing or no change flow to be readily seen and understood on a single graph. Flow pulse reference lines can easily be added and interpreted. The methodology is based on the time-series serial correlation lag-1 graph and uses the normally unwanted (but still valuable) autocorrelation present within the streamflow data. Examples and applications are included.Key words: Lag-1 hydrograph, autocorrelation, 1st, 2nd order derivative, hydrograph analysisIntroductionHydrographs are an essential tool for hydrologists or other water resources professionals. The USGS defines a hydrograph as a graph showing stage, flow, velocity, or other property of water with respect to time. (Langbein and Iseri, 1960). Note there is no rigid requirement that a time axis be used when plotting time-base data, though this is the most common method. Another approach is demonstrated in this paper.Lag-1 Hydrograph MethodData preparation and plotting are identical to an autocorrelation lag 1 plot, where 1 indicates a 1-day time shift. Table 1 shows how the time-series discharges are shifted. For this paper, the unshifted discharge is labeled Qt (the x coordinate) and the shifted discharge Qt+1 (the y coordinate). It is critical that the temporal sequence is maintained for the data. Thinking of the x values as flow for today and the y values as flow for tomorrow helps to visualize the order of the data. Table 1. Data shift example (USGS site Colorado River at Lees Ferry, AZ)To calculate discharge change, a ratio between the coordinates is used. This ratio can be used as a reference on the plot. For these equations below, the (x,y) coordinate is (Qt, Qt+1). In all cases there is a 1-day time step so that the change in time (Dt) is 1.Equation 1a y = mx Equation 1b Qt+1 = m Qtwhere m = change ratioEquation 2 m = y/x = (Qt+1) / (Qt) where m > 1, discharge is increasing m = 1, no change to discharge m < 1, discharge is decreasing Equation 3a y x = Qt+1 Qt = DQ/day Equation 3b (m 1) Qt = Qt+1 Qt = DQ/day A traditional line hydrograph for the data in Table 1 is shown in Figure 1.Figure 1. Line hydrograph for the Colorado River at Lees Ferry, AZ The hydrograph represents runoff from a Pacific hurricane remnant that crossed into the southwestern United States (Weaver, 1968). The multiday event provides a useful example to display and discuss properties of the Lag-1 hydrograph.A key item with this approach is that time is employed as a data attribute rather than as a coordinate. The lag-1 hydrograph (Figure 2) allows for additional information such as regions of increasing, decreasing or no change in discharge. An interesting feature of this plot is that the first and second order derivatives of the discharge are displayed.Consider the following data representations on a Lag-1 hydrograph:1. The x coordinate of a data point represents the daily discharge (Qt)2. Each data point represents DQ/day or dQ/dt (1st order derivative)3. Lines connecting points represent D(DQ/day) or d2Q/dt2 (2nd order derivative)The details listed above are comparable to distance (item 1), velocity (item 2), and acceleration (item 3) from the physics of motion. Regions are highlighted below. Figure 2. Lag-1 hydrograph example (day number associated with Qt).ResultsFigures 1 and 2 use the same data but display very different graphics.Below are detailed comparisons of the two plots:Days 11 to 12 The line hydrograph shows little change between these two days, while the lag-1 hydrograph shows a single point very close to the y = 1x ratio change line.Days 12 to 13 and 13 to 14 The line hydrograph shows the rising limb of the event. The lag-1 hydrograph shows days 11, 12, 13, and 14 are all above the 1x line, indicating rising flow conditions. But because the distance of the points decreases from the 1x line, this shows the increases are occurring, but at a decreasing rate. Day 14 shows the peak for Qt+1, while Day 15 shows the peak for Qt. Both represent the discharge on 15 Sept 1927. Days 15, 16, 17 and 18 the line hydrograph shows decreasing flows. The lag-1 hydrograph also shows the decreasing flow conditions as all points are below the 1x line. Additionally, the rate of change for the decrease is consistent. A power curve fitted to these points yields a recession equation for the general form aQb where Qt+1 = 1.8124 Qt 0.9198. This is consistent with the extraction method of baseflow recession segments based on a second-order derivative (Yang, et al., 2020).Discussion & ConclusionThis paper is a brief overview of a new technique that does not appear elsewhere in the published literature. Here are three ways this technical approach can be used in water resources projects. First use this method for model calibration by having the x axis be the observed data and the y axis be the modeled data. The resulting plot would be an error hydrograph showing time and discharge differences. Next scale up the data used from one runoff event to a multi-year discharge record with the x axis as Qt and the y axis as Qt+1. The resulting plot becomes an autocorrelation lag 1 plot but now with the Q, dq/dt and d2Q/dt2 regions. Additionally, the autocorrelation r(k), a metric of persistence and randomness, can be calculated. Finally let an upstream gaging station be the x axis and a downstream station, lagged by the routing time, be the y axis. The resulting plot will show the contribution of the local, ungaged area between the two stations.A more in-depth treatment of this novel approach is available as a webinar (June 16, 2022) sponsored by the American Institute of Hydrology (AIH webinar, 2022).RemarksThe author thanks AIH for the opportunity to share this self-funded research. ReferencesAIH webinar. 2022. A Novel Approach to Quantify Streamflow Properties, W. B., and Iseri, Kathleen T., 1960. General Introduction and hydrologic definitions: U.S. Geol. Survey Water-Supply Paper 1541-A, 29 p.Weaver, R. 1968. Meteorology of Major Storms in Western Colorado and Eastern Utah. Technical Memorandum WBTM HYDRO-7. U.S. Dept. of Commerce, Environmental Science Services Administration, Weather Bureau.Yang, W., C. Xiao, and X. Liang. 2020. Extraction Method of Baseflow Recession Segments Based on Second-Order Derivative of Streamflow and Comparison with Four Conventional Methods. Water. 12. 10.3390/w12071953. About the AuthorDr. Koehler is the CEO of Visual Data Analytics and a certified professional hydrologist with over 40-years experience. Previously he was the National Hydrologic and Geospatial Sciences Training Coordinator for NOAAs National Weather Service and is a retired NOAA Corps lieutenant commander. Assignments included navigation and operations officer for two NOAA oceanographic research ships, the Colorado Basin River Forecast Center and the Northwest River Forecast Center where he oversaw the implementation of an operational dynamic wave model for Lower Columbia River stage forecasts. Other positions include Director of Water Resources for an Arizona consulting company and the water resources hydrologist for Cochise County, Arizona. He is also a member of the science department faculty at Front Range Community College and is instructor for astronomy, geology, geography, GIS and geodesy courses. He is also an FAA certified professional drone operator.He has a PhD, MS and BS in Watershed Management from the University of Arizona and an additional MS in Hydrographic Sciences from the US Naval Postgraduate School. The focus of his research are alternate methods of analyzing environmental time-series data along with associated data visualizations. River discharge is the volume of water flowing through a river channel. This is the total volume of water flowing through a channel at any given point and is measured in cubic metres per second (cumecs). The discharge from a drainage basin depends on precipitation, evapotranspiration and storage factors. Drainage basin discharge = precipitation evapotranspiration +/- changes in storage.Storm HydrographsHydrographs can be used to illustrate discharge. These can be used to show annual discharge patters of flow in relation to climate. Over the short term, a flood or storm hydrograph (figure 1.) can be used to show short term variations. They cover a relatively short time period, usually hours or days rather than weeks or months. Storm hydrographs allow us to investigate the relationship between a rainfall event and discharge.Figure 1. A storm hydrographThe starting and finishing level show the base flow of a river. The base flow is the water that reaches the channel through slow throughflow and permeable rock below the water table. As storm water enters the drainage basin the discharge rates increase. This is shown in the rising limb. The highest flow in the channel is known as the peak discharge. The fall in discharge back to base level is shown in the receding limb. The lag time is the delay between the maximum rainfall amount and the peak discharge.The shape of a hydrograph varies in each river basin and each individual storm event. The hydrographs below show two contrasting environments.Before Urbanisation Figure 2. Hydrograph before urbanisationRural areas with predominantly permeable rock increases infiltration and decreases surface runoff. This increases lag time. The peak discharge is also lower as it takes water longer to reach the river channel.Figure 3. Hydrograph following urbanisationUrbanisation is the main human impact on a storm hydrograph. Surface runoff increases when areas are urbanised due to the removal of top soil and vegetation. As roads, pavements and buildings are constructed the surface becomes impermeable. Laying drains leads to the rapid transportation of water to river channels which reduces the lag time.Physical factors affecting storm hydrographsThere is a range of physical factors that affect the shape of a storm hydrograph. These include:1. Large drainage basins catch more precipitation so have a higher peak discharge compared to smaller basins. Smaller basins generally have shorter lag times because precipitation does not have as far to travel. The shape of the drainage basin also affects runoff and discharge. Drainage basins that are more circular in shape lead to shorter lag times and a higher peak discharge than those that are long and thin because water has a shorter distance to travel to reach a river.2. Drainage basins with steep sides tend to have shorter lag times than shallower basins. This is because water flows more quickly on the steep slopes down to the river.3. Basins that have many streams (high drainage density) drain more quickly so have a shorter lag time.4. If the drainage basin is already saturated then surface runoff increases due to the reduction in infiltration. Rainwater enters the river quicker, reducing lag times, as surface runoff is faster than baseflow or through flow.5. if the rock type within the river basin is impermeable surface runoff will be higher, throughflow and infiltration will also be reduced meaning a reduction in lag time and an increase in peak discharge.6. If a drainage basin has a significant amount of vegetation this will have a significant effect on a storm hydrograph. Vegetation intercepts precipitation and slows the movement of water into river channels. This increases lag time. Water is also lost due to evaporation and transpiration from the vegetation. This reduces the peak discharge of a river.7. The amount precipitation can have an effect on the storm hydrograph. Heavy storms result in more water entering the drainage basin which results in a higher discharge. The type of precipitation can also have an impact. The lag time is likely to be greater if the precipitation is snow rather than rain. This is because snow takes time to melt before the water enters the river channel. When there is rapid melting of snow the peak discharge could be high.Human factors affecting storm hydrographsThere is a range of human factors that affect the shape of a storm hydrograph.These include:1. Drainage systems that have been created by humans lead to a short lag time and high peak discharge as water cannot evaporate or infiltrate into the soil.2. Areas that have been urbanised result in an increase in the use of impermeable building materials. This means infiltration levels decrease and surface runoff increases. This leads to a short lag time and an increase in peak discharge.Key TermsHydrograph a graph that shows river discharge and rainfall over time.Flood when the capacity of a river to transport water is exceeded and water flows over its banks.Base flow The base flow of the river represents the normal day to day discharge of the river and is the consequence of groundwater seeping into the river channel.Storm flow storm runoff resulting from storm precipitation involving both surface and through flow.Bankfull discharge the maximum discharge that a particular river channel is capable of carrying without flooding.Peak discharge the point on a flood hydrograph when river discharge is at its greatest.Peak rainfall the point of a flood hydrograph when rainfall is at its greatest.Lag time period of time between the peak rainfall and peak discharge.ShareBy Denver Kunaka, Updated March 20, 2025 A storm hydrograph/flood hydrograph is a graph showing the relationship between rainwater and discharge in a river. Discharge is the water flowing in a river in a given unit of time. The storm hydrograph is mainly used to observe discharges for given storm events. The storm hydrograph has these properties:BaseflowWater supplied to the river by the slow seepage of water from groundwater. The response of baseslow to rain is slow and can be negligible.Rising LimbWater entering the river, steeper rising limbs indicate fast entering of water into the riverPeak DischargeFlow of water is at its highest.Lag TimeLag time is the time between highest rainfall and peak discharge.Falling/Recession LimbShows falling discharge in a river.Approach SegmentThis shows a rivers flow before a storm. When a storm begins rain does not readily enter into the river and fills it, instead, most contributions comes from overland flow(runoff) or throughflow. Short lag times indicate that rain is heavy and entering the river fast. Long lag times indicate that rain water(runoff) is slowly reaching the river.Storm Hydrograph src AlevelGeography.comFactors Affecting the Storm HydrographSeveral factors affects the time water reaches a river and its discharge.PrecipitationHeavy, sudden bursts of rainfalls leads to steep rising limbs and short lag times. Water is not given time to infiltrate thoroughly. This is why in deserts dried up rivers quickly replenish after a heavy storm (flash floods). Conversely, light rains favours gradual and thorough infiltration, hence less water reaches the river. This results in long lag times. But if rainfall continues for a long period, the ground may become completely saturated and water can flow as saturation overland flow, this is typical of tropical areas.Nature of SurfaceIce covered surfaces hinders infiltration and encourage high run-off rates leading to higher discharges and short lag times. Baked surfaces in arid regions prevents infiltration and encourage more run-off. The results are high peak discharges and short lag times.Vegetation CoverVegetation can absorb and hinder surface runoff from reaching the river. In addition, densely vegetated areas in tropical regions can intercept rainwater and less water reaches the surface as runoff.Soil/Rock TypePorous soils such as sands or rocks such as limestone are permeable, therefore runoff is reduced and leading to long lag times and gentler hydrographs.SlopeOverland flow (run-off) is highest on steep slopes because infiltration is reduced, therefore water reaches the river fast (short lag time) and discharge is high.Basin Morphology and sizeSmall circular catchments will have short lag times as runoff water quickly reaches the river. High elevated basins results in high runoff rates which shortens the lag time.Human Impacts Affecting Storm HydrographsDeforestationLack of vegetation encourages high runoff rates. In addition, interception is reduced and water readily reaches the surface. This result in short lag times and high peak discharge.AfforestationConversely, dense vegetation cover hinders runoff and intercept more rainwater. In addition, roots absorb water which reduce runoff.UrbanisationRoads and pavements impedes infiltration and favours high runoff, thereby increasing surface runoff and short lag times and high peak discharges. Storm drains channels water to rivers increasing discharge. Urbanisation produce intense rainfalls and which increase the overall river discharge.Dam/ResevoirsDams stores water and blocks off the natural flow of the river. This can create long lag times.AgriculturePoor farming methods, tractors and cattle cane compact the soil creating a hard layer which hinders infiltration and encourage high runoff which in turn shorten the lag time. The removal of vegetation for farming also mean that run-off increases which shortens the time water reaches a river.Storm Hydrographs by regionTropicsSub-tropicsDeserts (Hot & cold)Temperateshapegentlefairly steepvery steepfairly steeplag timelonglong-shortshortlong-shortNB: It is important to note that tropical storm hydrographs are gentler for a given storm event, but long term discharge is usually high as water is abundant and flows as saturation overland flow.The regional storm hydrographs only shows a broader view of a typical storm hydrograph, but local and specific factors are the most determinants of a storm hydrograph.For example, we can have pavements in a particular tropical region area or steep slopes as well which both increase discharge and shortens the lag time.A typical tropical storm hydrograph: Not for scaleThe discharge of a river (or stream) is the volume of water that flows past a point in the rivers course per second. The volume is measured in cubic metres (m3) and its per second so the units of discharge are cubic metres a second or m3s-1. Coincidentally, 1m3s-1 is the same as 1 cumec so the discharge of a river is often measured in cumecs because its a bit easier to say. Discharge is normally measured at gauging stations that are situated at different points along the river.The discharge of a river changes over time depending on a few factors. The most influential factor is the weather. After heavy rainfall the discharge of the river will be higher because theres more water entering the river. The weather affects discharge so much that theres a special graph that we can draw called a hydrograph which shows precipitation and discharge on the same graph and makes it easy to see how quickly precipitation affects the discharge of a river. A storm hydrograph is a specific type of hydrograph that, surprise, surprise, shows precipitation and discharge during and after a storm. The main difference between a normal hydrograph and a storm hydrograph is that a storm hydrograph is over a much shorter period of time. Below is a storm hydrograph for the fictional River Shui:Theres a curve showing the discharge of the river and theres a series of bars showing some (fairly heavy) precipitation. Theres a few things to note on this graph. First is the lag time. The lag time is the time difference between the peak precipitation and the peak discharge. A long lag time indicates that its taking a long time for precipitation to enter the river. Conversely, a short lag time indicates that the precipitation is entering the river fairly quickly. The rising limb is the steep part of the discharge line that has a positive gradient, indicating that the discharge is increasing. The falling limb is the opposite showing that the discharge is falling.Factors Affecting a Storm HydrographThe Drainage BasinThe shape of a hydrograph is altered by a few different things. One factor is the shape of the drainage basin. Drainage basins come in a wide assortment of shapes. (Roughly) Circular shapes are common as are more elongated and narrow shapes. For a circular drainage basin, the rivers hydrograph can often be described as flashy because it will have a fairly steep rising limb and a high peak discharge. This is because all points in the drainage basin are (again, roughly) equidistant from the river so all the precipitation reaches the river at the same time.The size of the drainage basin obviously has an impact on the hydrograph. Large basins will have high peak discharges because they catch more precipitation but at the same time theyll have longer lag times than small basins because the water takes longer to reach the rivers.Basins with steep slopes will have a high peak discharge and a short lag time because the water can travel faster downhill. Finally the drainage density of a basin will affect the lag time and the steepness of the falling limb. Basins with lots of streams and rivers (a high drainage density) will have a short lag time and a fairly steep falling limb because water will drain out of them quickly.Soil & Rock TypeIf a river is surrounded by non-porous and impermeable rocks (e.g., mudstone) its going to have a high peak discharge and a short lag time. Impermeable rocks wont let water percolate through them, forcing the water to travel via overland flow. This is much faster than groundflow, interflow and throughflow so the lag time is reduced. Furthermore, non-porous rocks cant store water so the peak discharge of a river is increased as more water enters the river rather than being stored in the drainage basin.The soils ability to let water infiltrate has a similar effect to the dominant rock type in a drainage basin. Unconsolidated soils allow water to infiltrate and so act as a store in a drainage basin. In addition, water travels slowly through soil via throughflow. This reduces the peak discharge while increasing the lag time of a river. On the other hand, extremely fine clay soils dont allow water to infiltrate. As a result, water travels quickly as overland flow, reducing the lag time of a river.Weather & ClimateThe intensity of a storm will obviously impact the peak discharge of the river. More rainwater = more water in the river so a higher discharge. Not immediately obvious is the type of storm (or precipitation) that takes place. A winter storm (i.e. snow) will result in an increase in the rivers discharge when the snow melts but this often wont be for a long time, so the lag time will be huge.If its been raining heavily previously, the ground may be waterlogged so the lag time will be reduced because water will be unable to infiltrate and will instead travel via overland flow. Similarly, if the climates been hot & dry or freezing cold the ground will be hard and water will once again be unable to infiltrate and will instead travel as overland flow, reducing the lag time and increasing the peak discharge.Vegetation CoverIf the area surrounding the river has thick vegetation cover then lots of precipitation will be intercepted, greatly increasing the lag time. In addition, the peak discharge will decrease because vegetation will absorb the water and lose it through transpiration and evaporation.Human ActivityHumans will normally cover soil in impermeable materials like tarmac or concrete which will increase surface run off and reduce the amount of water being stored, increasing the peak discharge and reducing the lag time. As water doesnt infiltrate easily in urban areas humans often build storm drains that run directly into a river, reducing the lag time and increasing the rivers peak discharge.Analysing Storm HydrographsIts very common for questions about hydrographs to come up in the exam but thats OK, these are normally 2 or 4 mark questions that ask you to read something off a graph or describe the graph. Easy marks. The ever so slightly harder questions are the ones that ask you to explain a hydrograph because these require you to think. Lets look at the storm hydrograph for the fictional River Shui again:If asked to describe the hydrograph you could quote the lag time, peak discharge and comment on the steepness of the rising and falling limbs (remember, state values off of the graph). Instead, you could be asked to explain the hydrographs shape. These reasons are essentially all the factors we discussed previously. You need to state a factor and then explain how and why it affects the shape of the hydrograph.For the River Shuis hydrograph, we could say that the high peak discharge and the steep rising limb suggests that the drainage basin is circular because if it was, the precipitation will land at points equidistant from one another and reach the river at roughly the same time, producing the high peak discharge. Storm hydrographs' shape depends on physical features of drainage basins (size, shape, drainage density, rock type, soil, relief and vegetation) as well as human factors (land use and vegetation) (P: the role of planners in managing land use) Whereas river regimes are usually graphed over the period of a year, storm hydrographs show discharge changes over a short period of time, often no more than a few days. The storm hydrograph plots two things: the occurrence of a short period of rain (maybe a heavy shower or storm) over a drainage basin and the subsequent discharge of a river.Main features of a hydrograph:`Once the rainfall starts, the discharge begins to rise - rising limbPeak discharge is reached some time after the peak rainfall because the water takes time to move over and through the ground to reach the river.The time interval between peak rainfall and peak discharge is known as lag time.Once the input of rainwater into the river starts to decrease, so does the discharge; this is shown by the falling or recessional limbEventually the river's discharge returns to its normal level, or base flow.The shape of a storm hydrograph of the same river may vary from one rain event to the next. This variation is closely linked to the nature of the rainfall event. The shape of the hydrograph also varies from one river to another. This is a result of the particular physical characteristics of individual drainage basins.Some hydrographs have very steep limbs, especially rising limbs, a high peak discharge and a short lag time. These are often referred to as 'flashy' hydrographs. In contrast, there are some hydrographs with gently inclined limbs, a low peak discharge and a long lag time. These are called 'delayed', or 'flat' or 'subdued' hydrographs. UrbanisationWhen it comes to evaluating the factors affecting the character of storm hydrographs, particularly their 'flashiness', none is more important than urbanisation. Not least of its impacts is that it changes the characteristics of the land surface. Its effects on hydrological processes include the following:Construction work leads to the removal of the vegetation cover. This exposes the soil and increases vegetation coverBare soil is eventually replaced by a covering of concrete and tarmac, both of which are impermeable and increase surface runoff.The high density of buildings means that rain falls on roofs and is then swiftly fed into drains by gutters and pipes.Drains and sewers reduce the distance and time rainwater travels before reaching a stream or river channel.Urban rivers are often channelised with embankments to guardagainst flooding. When floods occur, they can be more devastating.Bridges can restrain the discharge of floodwaters and act as local dams, thus prompting upstream floods.In short, the overall impact of urbanisation is the increase the flood risk. The problem is made worse by the fact that so many towns and cities are located close to rivers. Historically, this was for reasons of water supply and sewage disposal. Often the historic nucleus was located at a point where a river could be easily crossed.Synoptic themesPlanners have become important players in managing the impacts of urbanisation on flood risk. This is because:many towns and cities are naturally prone to flooding because of their locationsof the number of people who live in urban places and who therefore need protectionof the huge amount of money invested in urban property.Flood risk management involves such actions as:strengthening the embankments of streams and riversputting in place flood emergency proceduressteering urban development away from high-risk areas such as floodplains Factor 'flashy' river 'flat' river Description of hydrograph Short lag time, high peak, steep rising limb Long lag time, low peak, gently sloping rising limb Weather/climate Intense storm that exceeds the infiltration capacity of the soilRapid snowmelt as temperatures suddenly rise above zeroLow evaporation rates due to low temperatures Steady rainfall is less than the infiltration capacity of the soilSlow snowmelt as temperatures gradually rise above zeroHigh evaporation rates due to high temperatures Rock type Impermeable rocks, such as granite, which restrict percolation and encourage rapid surface runoff. Permeable rocks such as limestone, which allow percolation and so limit rapid surface runoff. Soils Low infiltration rate, such as clay soils (0-4mm/h) High infiltration rate, such as sandy soils (3-12mm/h) Relief High, steep slopes that promote surface runoff Low, gentle slopes that allow infiltration and percolation Basin size Small basins tend to have flashy hydrographs Larger basins tend to have more delayed hydrographs; it takes time for water to reach gauging stations Shape Circular basins have shorter lag times Elongated basins tend to have delayed or attenuated hydrographs Drainage density High drainage density means more streams and rivers per unit area, so water will move more quickly to the measuring point. Low drainage density means few streams and rivers per unit area, so water is more likely to enter the ground and move slowly through the basin Pre-existing (antecedent) conditions Basin already wet from previous rain, water table high, soil saturated, so low infiltration/percolation Basin dry, low water table, unsaturated soils, so high infiltration/percolation Vegetation Bare/low density, deciduous in winter, means low levels of interception and more rapid movement through the system Dense, deciduous in summer, means high levels of interception and a slower passage through the system; more water lost to evaporation from vegetation surfaces Human activity Urbanisation producing impermeable concrete and tarmac surfacesDeforestation reduces interceptionArable land, downslope ploughing Low population density, few artificial impermeable surfacesReforestation increases interceptionPastoral, moorland and forested land

Human factors affecting flood hydrographs. Factors affecting hydrograph. Human factors affecting storm hydrograph. Human factors affecting water availability.