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Wintergreen Brook

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by Bill Duesing

INTRODUCTION

Wintergreen Brook is a body of water about five miles long which flows on the east side of West Rock from a point near the north end of Mountain Road in Hamden south through Lake Wintergreen and joins the West River north of Whalley Avenue between Blake and Fitch Streets in New Haven. Just after it goes under the Wilbur Cross Parkway, Wintergreen Brook comes into contact with the West Rock Nature Center near the entrance. The brook falls quickly at first and then levels out as it flows near the south boundary of the Nature Center.

This unit will focus on Wintergreen Brook with emphasis on its association with the Nature Center where High School in the Community teaches an Ecology course each spring. This unit will use a combination of map and field studies to provide a basic understanding of the concepts of watershed and the water cycle, stream flow and the effects of water on the earth's surface.

The primary objective of this unit is to have students understand geological and hydrological processes and evolution through a combination of map and field studies relating specifically to Wintergreen Brook and the surrounding land. This includes the historic events which shaped this area and the ongoing effects of the water on the area. Other objectives are to have students understand basic concepts dealing with water quantity including rainfall, stream flow and urban water use. Students will also calculate the power generation potential of the brook and be exposed to and experience the natural world as they carry on these activities and work together to make measurements and drawings.

The Ecology course begins with a study of major living and nonliving components of the ecosystem, the biosphere, the atmosphere, the hydrosphere and the lithosphere. The first objective provides a local, relevant, in depth learning experience relating to the last two components. It also provides an illustration of two other concepts which are important in the Ecology course. The first is the concept of geological time and the changes which have occurred in all of the earth's components. Another important concept is the difference between the movement of energy and the movement of materials in an ecosystem. It is important for students to understand that energy moves in a one way flow, from more useful to less useful, while materials are always recycled.

This is clearly illustrated as we see how the stuff the earth is made of moves around and takes different forms, but is always the same atoms and elements, whereas the energy that is given to water molecules as they are lifted up by the sun is expended, transferred into nonusable forms, as gravity pulls the water from the sky down over the land, through the brook to the sea.

As the students study the origins and topography of West Rock and Wintergreen Brook as well as their inseparable relationship, they will also be exposed to basic geological and hydrological processes.

Study will begin with a visit to the site to explore as much of the topography as possible. With the brook as the focus, students will learn that in any area the brook occupies the lowest point and the ground rises to either side from there. They will also see that the land rises much higher on the west, up to the top of West Rock. This kind of cross sectional view should be done in several places which will also provide information about the direction of the flow of the brook and the lay of the land.

(Although this type of site visit is quite possible with the Ecology course, and would be useful with other classes, a slide set has been developed which illustrates the major points needed to follow along with the other learning experiences in this unit.)

With first hand experience of how this area looks, students are ready to look at maps as the first step in the more abstract process of understanding the evolution of this area.

MAP STUDY

The first maps that are needed are the New Haven and Mount Carmel Quadrangles of the United States Geological Survey topographic maps. In order to become familiar with the maps and their accuracy, each student will find his or her home and school. (An optional exercise for advanced students would be to express these locations as longitude and latitude and understand how these angular measurements are used to locate points on the globe.) Then the idea of scale is introduced. These maps are 1:24,000, or every distance is really 24,000 times as far as it is on the map. This can be demonstrated by taking the length that represents a mile or a kilometer on the map scale and multiplying it by 24,000. Using either the multiplying length method or the scale each student will determine the distance from home to a point of interest. In the course of this exercise students will become familiar with the main symbols used in the map and the use of the key, which is available separately.

The next aspect of map reading is the contour lines and how they define the shape of the land. To understand this each student will draw a cross section of a different point on the brook, including some of the places where the field visits were made. An enlargement of the topo maps would be useful for this exercise. A straight edge should be positioned roughly perpendicular to the brook at regular intervals, and the contour lines marked where they cross the straight edge (paper). The results should be transferred to another paper. If one cross section is made with the elevations to scale, the students will see that at the scale of these maps, there is very little vertical change. If the vertical scale is exaggerated it will present a more obvious idea of the shape of the watershed. An exaggeration of 3:1 (each vertical distance is three times the scale of each horizontal distance) is used in making raised relief maps and could be used here (see illustration).

If these are done at regular intervals they will be useful for the next exercise. The contour drawings should extend beyond the nearest high points. They then will give students a very clear picture of watershed or drainage basin. They will see which way the rain will run off. Information from the depth to bedrock map and contour map of the bedrock surface could be added to help visualize underground flow. The similarity of the bedrock and surface contours and the evenness of the depth to bedrock will help students understand that the irregular surface of the land follows closely the surface of the bedrock underneath.

After the cross sections are done, students will be able to draw the outline of the watershed on the map.

Next a similar exercise should be done for the length of the brook from the highest ground near Mountain Road in Hamden to the Long Island Sound. The part from the beginning through the Nature Center should be done in greater detail than the rest. These two exercises should provide a very good feel of the topography of the area under study and prepare the students to see how this area has changed in the last 200 million years.

SURFICIAL GEOLOGY

A good place to start the study of geology is with the surficial geology maps of the area under study. Aside from differences in buildings and roads due to different dates of the maps, the major difference is that instead of using colors to show house omissions (pink), woods (green), and open area (white), the geologic map uses colors to illustrate the different materials of the surface of the land. An understanding of the five different types of material and why and how they occur is important to this study. The majority of the Wintergreen Brook watershed above the Nature Center is composed of glacial till. Also present are bedrock, of two distinct types (sandstone and trap rock), ice-contact stratified drift, artificial fill, and outwash sands and gravel. The last type of material is not shown on the quadrangle maps, but is shown on the Water Authority report on Lake Wintergreen.

The first step back in geological time is to the period 15-20,000 years ago when this area, like all of New England was buried under a one mile thick sheet of ice. As the ice advanced from the north it scoured the surface of the land, removing softer material, pushing it on ahead and changing the shape of harder material. The large boulder which makes Judges' Cave is an erratic or rock that was brought there by the glacier. Just north of there are striations made on exposed bedrock by glaciers.

The fact that West Rock is still much higher than the land near the brook indicates that there must have been different materials in each place when the glacier pushed through. It exposed the harder bedrock of West Rock (now covered in some places by a thin soil made by the soil building processes of water, weather and plants since the glacier melted). In the lower areas the glacier left the various types of sediments that are indicated on the map. Glacial till, indicated by green color on the map, is an unsorted compact sediment containing many sizes of particles. In an exposed area of till, students could see how many different kinds of rocks they can find and see that they are not like the two types of exposed bedrock in this area.

The glacially placed material indicated by pink on the geologic map is ice contact stratified drift. (Drift is an old word applied to glacially deposited materials. It derives from the earlier belief that these materials were deposited during Noah's flood. The theory's changed, the name remains.) This material is different from the till in that the different sizes of material, sand, gravel, and larger stones occur in layers roughly sorted by size. This occurred because, as the name implies, these sediments were deposited in contact with the glacier and the alternate freezing and thawing as the glacier retreated over the years produced these layered deposits.

The only location of ice-contact stratified drift upstream of the Nature Center is just west of the bend in Wintergreen Avenue just below the lake. This area is covered with vegetation so that the stratified nature of the deposits is not visible. Several slides of other areas will illustrate this type of deposits.

The outwash sands and gravel occur along the brook above the lake and the artificial fill occurs to create the dam which holds Lake Wintergreen, around the entrance to the Nature Center, and under the parkway.

One of the most interesting places, geologically, in this area, is the place where the water leaves the lake. It is near the middle of the east side of the lake. To the south of the exit the water is held in by a natural bedrock dike of trap rock. To the north of the exit the water is held in by the man-made dike (dam) made from blocks of the trap rock and earth. The land falls away quickly from the lake here, making for a beautiful waterfall as the water becomes a brook again. In the cut of the falls, the red sandstone is visible, in layers, with the glacial till on top of it. This is below the trap rock which forms the dike.

Seeing this leads us back in time to find out how these two different types of bedrock came to be in such close association here.

BEDROCK GEOLOGY

The two types of bedrock in the Wintergreen Brook-West Rock area (the same as under most of New Haven and the central lowlands of Connecticut) are the sedimentary sandstone called Arkose and igneous diabase or trap rock. To understand their formation and association here we need to go back to events that began about 210 million years ago.

It is important to realize that at the time of the glaciers this area wasn't so different from its appearance now. The shape of the land was close to its current shape and the oceans and continents would be recognizable with the main difference being that the sea level was much lower when so much of the fixed quantity of water on earth was locked up in the glaciers. This means that dry land extended nearly to the edge of the continental shelf off New England. Although any life would be very limited under a mile of ice, between glaciations and at other places in North America human beings were around and plants and animals would look familiar.

When we take the major step back to the Triassic period over 200 million years ago the world would look very different. The continents were joined into one mass, Pangaea II, 230 million years ago and by 190 million years ago they split into two land masses, Laurasia and Gondwanaland. Over this period of time the land that is today North America was astride the equator. Two hundred and ten million years ago the equator went through the present mouth of the St. Lawrence River and crossed the other edge of the future continent around Oregon. Twenty million years later this land mass had moved north so that the equator went through northern Florida and the north of Mexico.

There weren't any flowering plants but there were forests of Gymnosperms and ferns and the first dinosaurs and primitive mammals were just appearing. Just before this story starts all of what will be Connecticut was made of fairly continuous metamorphic rock, now about 600 million years old.

Two hundred and ten million years ago a large block of the metamorphic rock, extending from the eastern edge of the Connecticut valley to west of the Hudson River began to subside to form a large graben or trough.

It is believed that this occurred in response to the opening up of the Atlantic Ocean as Pangaea II split up. The land on either side of the graben rose while the land in the center continued to sink. In the end the vertical displacement between the top of the metamorphic rocks to the east and west and the bottom of the graben was over three miles (see illustration).

Over the next ten million years erosion of the high land rocks to the east and west brought sediment into the graben. There the sediment built up to form the New Haven Arkose which consists of pinkish, gray, brown and reddish arkosic sandstone and conglomerate with interbedded layers of reddish siltstone. Exposures of this stone along Wintergreen Brook in the Nature Center range from dark purplish red to lighter brick red. Just above the Lake the bedrock is gray sandstone. Just as happens today, the flow of water over distance sorts out particles by size so that larger boulders stayed near the outside edge of the graben while finer particles were carried further.

About 200 million years ago there were some episodes of volcanic activity. In this area the magma was trapped between the layers of the sandstone or pushed its way into vertical cracks. Trapped between the sandstone, the magma cooled very slowly and formed the igneous rock called diabase which makes up West Rock.

Several million years later movement within the earth caused an uplifting in the center of the graben which was accompanied by a subsidence of the edges. This created cracks and fissures in the sandstone and diabase layers as well as tilting of the layers toward the east in what had been the east (present day directions) of the graben and toward the west at the other side. This tilt is evident at the outlet of Lake Wintergreen and also along the brook just south of the Nature Center entrance. There was at least one more period of volcanic activities which intruded magma through a vertical crack in the West Rock sill to form the buttress dike at the south end of Lake Wintergreen.

While this was happening dinosaurs were at their zenith. The tracks which are preserved at Dinosaur State Park in Rocky Hill were formed as these large animals walked on layers of drying mud and sand in former lakes in the graben. During this time there were flying reptiles, small mammals and the first birds appeared.

Erosion, a constant and ever present force, continued through the Jurassic and Cretaceous periods and wore down the center of the uplifted area so that the deposits of sandstone and diabase from the Triassic period are completely worn away from the western highlands of Connecticut and New York east of the Hudson River. In the West Rock area the erosion was able to wear down more of the sandstone than of the diabase which led to the general positions of ridges and valleys which the glaciers covered but probably didn't change very much as far as general location.

Following the 20 million year period of intense and dramatic large scale movements in the earth of this area, there was a much longer period, until the Great Ice Age which began two or three million years ago, with less dramatic movements and the continuous work of erosion shaping the land. During this period North America drifted slowly north until it was in its present relationship with the equator. Dinosaurs became extinct, flowering plants appeared and diversified and the animal world evolved toward what we know today.

THE WATER CYCLE

Having seen how the land was shaped, we can turn to look at the present water cycle as it relates to Wintergreen Brook. All the water in the brook comes from the precipitation that falls on the watershed or drainage basin. The average annual precipitation is 46 inches although it can vary between 65 inches and 23 inches. The watershed of Lake Wintergreen is 1.0 square miles. Therefore, on the average 5,280 feet x 5,280 feet x 3.83 feet of precipitation fall which equals 106,867,190 cubic feet of water per year. There are 7.48 gallons in a cubic foot of water, so the average annual precipitation on the watershed of Lake Wintergreen is 799,366,580 gallons.

In an average first order basin east of the Mississippi River, of the precipitation, 91% is infiltrated (taken in by the soil) and 9% is not infiltrated. Of the 91% infiltrated, 8% is subsurface stormflow which is discharged into the stream or lake from minutes to days later, depending on soil type, time of year, vegetation and slope. Twenty-three percent is base flow (enters the water table) and is released to the stream hours to years later. The remaining 60% is evaporated from the soil or transpired by the plants.

Of the 9% not infiltrated, 1% is overland flow and 1% falls on the bodies of water and both end up in the stream or lake very quickly. The other 7% of this evaporates so that a total of 67% of the rainfall is evaporated leaving 33% available to flow down the stream. Thirty-three percent of 799,366,580 gallons equals 263,790,970 gallons of water that should leave Lake Wintergreen annually. (It is interesting that a lake evaporates about the same amount of water as an equal area of trees.)

One of the activities the students at the Nature Center will do is to measure the rainfall in a simple rain gauge. After each rain or once a week they can calculate how much rain fell on the watershed and the amount that travels each pathway back to the atmosphere. Diagrams will be drawn showing the various flows of precipitation on a cross section of the watershed.

Between 1863 and 1978 Lake Wintergreen provided water for the City of New Haven. The lake was created when an earthen dam was built by Fair Haven Water Co. to flood the bedrock basin. After they had used the water supply for 13 years, the Fair Haven Water Co. was bought out by the New Haven Water Company, which soon bought additional land in the watershed.

By 1920 the company needed additional water which was obtained by bringing water from Belden Brook, north of Wintergreen Brook, into Lake Wintergreen through a diversion pond and a canal. This added a drainage area of .56 square miles to the water supply or an increase of 56% in area. This water could be diverted by the use of a control valve at the gate house at the diversion pond. The canal is easily seen north of the lake where the channel is very straight with a dirt roadway on one side. Left alone, Belden Brook joins Wintergreen Brook one-quarter mile east of the Nature Center.

In 1978 the lake was taken out of the water supply system because strict new Federal standards would have required construction of a filtration plant. This would have been too expensive for the relatively small size of this water source.

In 1980 the spillway and the level of Lake Wintergreen were lowered ten feet at the request of the Corps of Engineers so that the dam could withstand the probable maximum flood which occurs once in 10,000 years.

Prior to the lowering, the lake could store 100 million gallons of water and with the Belden Brook Diversion it could safely supply 800,000 gallons per day to the city.

WATER USE

Each student can calculate his or her water use and how it relates to rainfall and land area. The average water consumption is between 55 and 75 gallons per person per day, or 20,075 to 27,375 gallons per person per year. Of this 40% is used for the toilet, 30% is used in the bathroom sink and shower, 15% is used in the laundry, 10% is used in the kitchen and 5% is used outside. Looked at another way, 97% is used to transport wastes and 3% is used for drinking and cooking.

If we divide the water available by the daily usage we find that Lake Wintergreen could provide water to between 10,666 and 14,545 people. The article "Metabolism of Cities" says that a modern city of one million people takes in 625,000 tons of water per day and gives off 500,000 tons of sewage water with 120 tons of suspended solids in it. Water weighs 62 pounds per cubic foot. Six hundred twenty-five thousand tons/day x 2000 lb./ton x 1 cu. ft./62 lb. x 7.48 gal./cu. ft. = 150,800,000 gal./day Ö 1,000,000 = 150 gal./person/day.

This points out the fact that collections of people use two to three times more water than is individually used. Of the 150 gallons per person per day, an average of 65 gallons per day are for household use, 15 gallons per day are lost in leaks and an equal amount is used for street cleaning and fire fighting. The remainder, 55 gallons per day, is used by commerce and industry. One hundred fifty gallons/person/day x 365 days/year = 54,750 gallons per person per year in a modern city.

WATER POWER

Having calculated the water quantities in the watershed it will be interesting to calculate the flow of water in the stream which drains Lake Wintergreen. This can be conveniently done by the float method where the stream flows over a concrete bottom and between concrete sides under the Wilbur Cross Parkway. Although this method isn't the most accurate, it doesn't require construction in the stream and should be sufficient for the purposes of this course and provide an understanding of what stream flow means.

Two points are chosen at least 30 feet apart and are marked on both banks. The cross sectional area of the stream is calculated at each end. (If there were more variation in the shape of the stream, more cross sections should be taken to get a good average.) A float is then placed in the water at the upstream mark and is timed until it reaches the downstream mark. The result in square feet of section times the feet of distance traveled divided by the time in seconds equals the cubic feet per second, times 7.48 gallons per cubic foot equals gallons per second.

The inaccuracy in this method lies in the friction between the water and the concrete on the sides and bottom which slows down the water. Concrete has a lower friction effect than most natural stream bottoms, but this method will still overestimate stream flow.

This simple measurement could be repeated several times to see how the stream flow varied. The stream flow could also be multiplied by time until it reached a year to see how it compared with the calculated excess from the Lake Wintergreen watershed. It should be remembered that the stream flows for about 3000 feet from the lake to the parkway and during this distance it receives water by the same processes which provide water to the lake. Seasonal variation in streamflow should also be kept in mind. Most streams have highest flows in late winter and spring, and lowest flows in late summer, early fall. In this case the lake should act as a capacitor would in an electric circuit, moderating and evening out the stream flow.

Once the flow is determined it will be interesting to determine the power that would be available from the stream to turn a turbine to produce electricity. The formula for gross horsepower is the minimum water flow (in cubic feet/sec.) times the gross head in feet divided by 8.8.

If the minimum flow measurement isn't available, whatever measurement is available should be used as long as a lower limit to year round power production is understood. Head is the measurement of the distance the stream falls. Just south of the Nature Center entrance the stream falls very quickly so this would be a good place to think about a water power site. Head is traditionally measured with a transit, making a series of level lines and height measurements. It might be easier and more interesting with the students to use the hose method. Here a siphon is started from the higher water area using a long garden hose. The lower end is raised until the water stops flowing. At this point the height of the hose is about the same at both ends. The distance of the downstream end of the hose above the stream is the head. This may have to be done several times if the head is high.

The gross horsepower can then be calculated. Factors which will reduce this amount of power in an actual water power installation, besides lower stream flow, are friction losses in the system used to carry the water from the higher area to where the power unit would be located at the low point. Other factors which reduce final power are turbine efficiency less than 100% and transmission losses from production point to the power use site. Several sources of information about small generators are listed on the resource sheet.

CALCIUM

Another interesting place where the geology of Connecticut meets the Ecology course is in the movement of calcium atoms from tiny marine organisms 300-500 million years ago to this teacher talking or a student playing volleyball at the annual school picnic.

Absolutely essential for any muscle contraction is the presence of calcium ions attached to the thin fibers of the muscle. The calcium must come from foods. Some of the calcium the students get comes from the green leafy vegetables in the Nature Center garden, kale, turnip greens, lamb's quarters and others. Some of the calcium the teacher gets comes from milk from the cow which grazes in Oxford. Both the garden and the pasture have had ground dolomite limestone applied in order to supply calcium and magnesium as well as to raise the pH or acid-alkaline level to near neutral. The limestone is ground up marble which is mined in or near Canaan, in northwestern Connecticut.

In the early paleozoic era, starting about 570 million years ago, there was an ocean between two land masses which would eventually become North America and Africa. The edge of that ocean was in the area which is now Western Connecticut, although at the time it probably was the southern edge of the continent and was in the tropics. Under these conditions, diverse shell-secreting and other organisms thrived in the warm shallow water and over 80-100 million years built up a great carbonate bank from their remains. This thick layer of calcium containing deposits was sandwiched between a layer of sand and mud on the bottom which was eroded off the land to the (present day) west and a layer of mud and sand which washed in from the (present day) east as mountains were raised up in the ocean on that side.

This entire sandwich may have subsided much more, and then, through processes of temperature and pressure, the limestone sedimentary rock was turned into metamorphic marble which is found in the Housatonic Valley from Canaan to New Milford.

The long journey through time and space of calcium atoms, from tiny living creatures to sedimentary rocks to metamorphic rock, mined and powdered by humans and moved and applied to the soil where, with the help of soil microorganisms, they are taken up by plants and eaten directly by people or eaten by cows who pass it on to people in their milk shows that materials on earth are always recycled. We have only the atoms which have always been here.

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RESOURCES

The following materials will be useful in teaching this unit.

Maps:
Topographic maps of New Haven and Mount Carmel quadrangles

Surficial geology maps of New Haven and Mount Carmel quadrangles

Contour map of Bedrock Surface, New Haven-Woodmont quadrangles

Depth to Bedrock map, New Haven-Woodmont quadrangles

Bedrock Geology, Mount Carmel quadrangle

All of these maps are the same scale and are available from: Natural Resources Center

Department of Environmental Protection
165 Capitol Avenue, Room 553
Hartford, CT 06106
Telephone: (203) 566-3540

A good copy shop can make clear enlargements up to 161% of these maps which are useful for map exercises.

A slide set made to go with this unit is available through the Teachers' Institute or this author.

Information on small scale water power generators is available from:

Independent Power Company
12340 Tyler Foote Rd.
Nevada City, CA 95959
Burkhardt Turbines
P.O. Box 1436
Ukiah, CA 95482
Harris Hydroelectric
632 Swanton Road
Davenport, CA 95017

Topographic Map

(figure available in print form)

161% Enlargement of Topographic Map

(figure available in print form)

Depth to Bedrock Map

(figure available in print form)

Bedrock Contour Map

(figure available in print form)

Sections—data from map.

(figure available in print form)

(figure available in print form)