PEBBLE WATCH

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This issue of Pebble Watch focuses on hydrology, groundwater and surface water interactions; geology; how scientists use data to better understand water flow; and how mining activities can affect the quality and quantity of water in an area. It includes an overview of "Report Series C: Surficial Geology" and "Report Series D: Groundwater Hydrology," which detail studies made by Pebble developers from 2004 to 2007.

Readers will learn:

- The basics of groundwater and the hydrologic cycle and why they matter
- How mining activities affect water quality and quantity
- Why the relationship between groundwater and surface water is important
- What groundwater modeling is, and some of the factors that make it complex
- What hydrologic and geologic data has already been collected in the Pebble project area, and how developers might use that information.

Visit us online

Visit www.pebblewatch.com for updated information related to the Pebble project, links to relevant data, and a calendar with upcoming events. You'll also find past issues of the newsletter, covering soil and sediment sampling, meteorology and water quality.

Ask our team

Do you have a question about the Pebble project, the permitting process or the details behind ongoing studies in the area? Submit your question to our team of scientists and science communicators at www.pebblewatch.com. We'll post an answer on the website, and may print it in an upcoming issue of the newsletter.

How Water Moves and Why it Matters

Water moves in a continuous cycle. It evaporates from the Earth's surface or transpires from plants as water vapor—then it settles back as condensation and precipitation, such as dew or rain or snow.

Surface water collects on the ground or as water bodies like streams, rivers or lakes.

Water also collects and travels below the earth's surface. Though hidden, this groundwater is a critical part of the water cycle, as it is by far the largest source of available fresh water on earth. Groundwater does not move like a stream, but travels much more slowly, within gravel, sand, and fractures in limestone or bedrock.

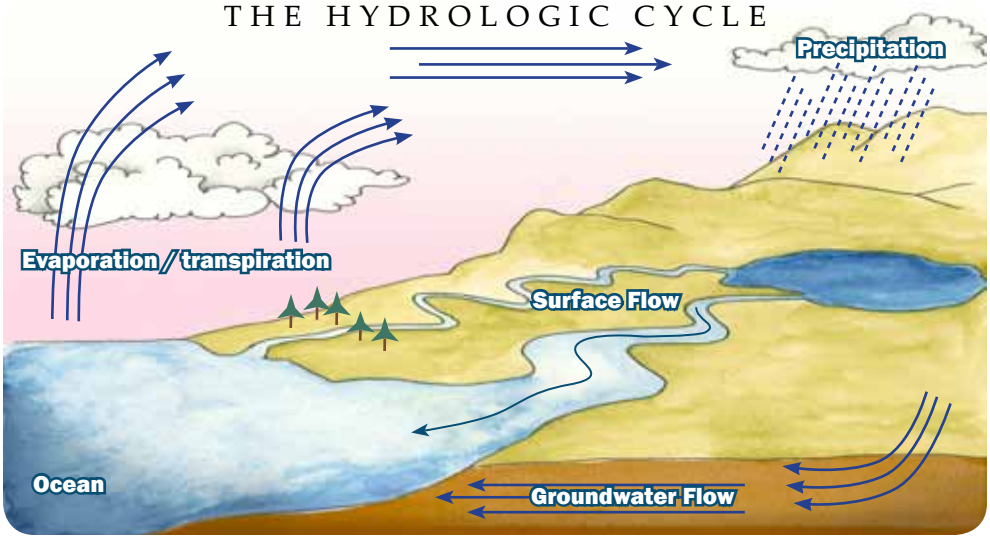
Hydrology is the scientific study of water and its movement, especially in relation to land. Understanding how water moves through an area is important to predicting how that area may be affected by development. Knowing how water moves both above and below ground helps to develop a picture of existing conditions and to forecast changes that may occur.

There is a give-and-take relationship between surface water and groundwater. Groundwater may be replenished (recharged) by rain, snow and other precipitation, or seepage from streams. In turn, groundwater may well up (discharge) to the surface to feed springs, streams, or smaller pools of water, called seeps—at which point it is considered surface water. Groundwater discharged in one area can travel as surface water in some areas and then be recharged into the ground miles away from its starting point.

The rate and amount of water flow from surface to underground and back again is influenced by many factors, including geology and seasonal changes in precipitation.

Because this interplay is so complex, and because groundwater is such an important resource, developers must have an in-depth understanding of regional hydrology to avoid groundwater depletion or contamination.

THE HYDROLOGIC CYCLE



Graphic: Bristol Creative Services

Mining and Water

Water Quantity

Too much groundwater can create unsafe conditions for mining, so engineers must create plans to "dewater" (remove water from) the work area. However, large quantities of water are also necessary for mining operations. For example, a July 2006 water rights permit indicated that estimated surface and groundwater usage in the proposed Pebble project area would equal more than 34 billion gallons a year. This would provide potable water for the camp and be used in activities such as processing ore, dust control, and tailings storage.

Water Quality

Sulfide mining carries an inherent risk of water contamination, since the waste it produces contains known toxins. Modern methods to minimize the risk of contamination include treatment and recycling of waste water when possible, and the containment of water used to stabilize tailings in a permanent tailings storage area. Knowledge of how water flows above and below ground can be used to understand where potential contamination might travel should it be released into ground or surface water, and to determine appropriate sites for tailings storage.

Using Data: Groundwater Studies

Pebble project developers have funded extensive groundwater studies in the proposed mine area. The Pebble Limited Partnership "Report Series D: Groundwater Hydrology," which covers data collection between 2004 and 2007, reports that these studies are important in order to minimize groundwater impact, include measures to mitigate residual effects, and identify optimal locations for mine facilities.

During the study, monitoring wells were used to collect groundwater samples and monitor groundwater levels. Piezometers, which are similar to monitoring wells, were also installed to measure groundwater levels. Data was collected from 259 wells located at 196 sites throughout the watershed areas of Upper Talarik Creek and the north and south forks of the Koktuli River. Data was recorded as frequently as hourly in some wells.

Rocks matter

Developers have been studying, or "characterizing," the surface and subsurface geology in the Pebble project area as well. They are measuring hydraulic conductivity (how fast water flows through soil and rock), as this is a major indicator of how closely groundwater and surface water are connected. Hydraulic conductivity is determined by the permeability and porosity of a material. For example, clays allow very little water transport, while coarse-grained material such as gravel allows water to fill in between the rocks and move through it faster.

Pebble Partnership's "Report Series C" delves further into the surficial geology of the Pebble deposit area, noting that the complex land formations were caused by four separate glacial episodes. These glaciers left behind sand, soil and rock in a number of moraines, meltwater deposits and outwash aprons.

How this data may be used

Pump test data helps determine how quickly groundwater recharges in an area after being pumped out. In addition, data from subsurface geologic tests can help assess hydraulic conductivity of different rock units, which impacts recharge rates. Ultimately, this data will be used to develop a groundwater model to evaluate potential changes in local and regional water tables, as well as groundwater interaction with local streams, wetlands and lakes.

Learn more...

For an overview of the studies, and to access more detailed documents, including locations of wells and drill holes, and data on pumping results and seep inventories, you can reference "Report Series C" and "Report Series D" online. Links to all the published data can be found under "Resources & Links" at www.pebblewatch.com.

During low-flow periods, surface water may disappear, as is evident in this image of the South Fork Koktuli River. Many factors affect the flow of water in a stream bed, including seasonal precipitation and the permeability of the underlying bedrock. Photo: Pebble Limited Partnership

Groundwater and surface water interactions

Why they matter

Historically, groundwater and surface water were evaluated as separate systems, but today they are considered one related resource. Alaska is one of the few western states that has adopted a conjunctive water rights management system, treating both groundwater and surface water the same from a regulatory standpoint.

Since groundwater can't be readily seen, there are significant challenges to understanding all the ways it interconnects with surface water, especially since these interactions can take place in a widespread area. As one example, Pebble project developers noted in the 2004 Baseline Studies Progress Report that some of the groundwater originating in the South Fork Koktuli River in the Nushagak watershed actually makes its way into Upper Talarik Creek, which is in the Kvichak watershed.

In and around the Pebble deposit, there is evidence of significant interaction between groundwater and surface water, including upwelling of groundwater into streambeds and land surface area as seeps. Published data show more than 4,500 documented seeps in an area about 193 square miles in size.

Cold groundwater upwelling through clean gravelbeds are important spawning sites for Bristol Bay salmon, making it necessary to understand how changes to groundwater might affect water flow, temperature and quality in those areas.

Flow – Mining activities such as dewatering will impact the existing hydrologic system and potentially change the location, quantity and timing of groundwater upwelling and recharge. Dewatering can reduce flow to surface water and lower groundwater levels to a depth below what vegetation/wildlife habitat needs to survive.

Temperature – The flow of groundwater into a stream moderates stream temperature, which has an impact on fish health and populations.

Quality – Movement of water between surface and ground water can also transport mine-related contaminants between the two, increasing the likelihood of uncontrolled releases. For a more in-depth discussion of water quality issues, see the Feb./March issue of the Pebble Watch newsletter at www.pebblewatch.com.

Studying and predicting

Understanding the complex movement and interaction of groundwater and surface water requires a variety of data. This can include the study of rock and soil to see how quickly water moves through it (hydraulic conductivity), and water monitoring to measure water level and how fast water is replenished. Visual observations and aerial photography are also sources of information (to inventory locations of seeps, for example).

Upper Talarik watershed: This photo illustrates how groundwater can well up to the surface, forming what is called a seep. There are more than 4,500 documented seeps in and around the Pebble deposit area. Groundwater also wells up into streambeds, providing a flow of water that helps stabilize water temperature during winter months. Photo: Pebble Limited Partnership

Data are used to chart typical conditions and seasonal changes, but it isn't possible to measure everything. That's why groundwater modeling is used to simulate how water moves in an existing system—and to predict changes that might occur if any known aspect of that system were to change. Modeling might be thought of as an equation where known information about an area is input—its geology, its surface water, groundwater and water flow—to understand what is not known. For example, such a model could be used to show how various locations for a mine tailings pond might affect ground and surface waters.

Such models provide a numerical 3-D overview of a water system. The type of program used and the data the model is built upon are critical for an accurate understanding of an area's hydrologic conditions.

Although a certain amount of site-specific assumptions are made during modeling, regulatory agencies have accepted this method for predicting how activities such as mining can affect hydrology in a specific area. Models also must be standard enough that they can be subject to independent testing and review by regulators.

In addition, current research highlights the need for models to take into account the uncertainty inherent in model predictions, and the impact of long-term climate changes on hydrology, instead of basing predictions on fixed parameters.

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INSIDE: HOW WATER MOVES AND WHY IT MATTERS

About Pebble Watch

Pebble Watch is an impartial, educational and fact-based initiative of the BBNC Land Department to disseminate information regarding the proposed Pebble Mine project to BBNC shareholders and interested parties. Pebble Watch does not attempt to integrate or interpret data; this would occur during an Environmental Impact Statement process. Instead, we seek to help BBNC shareholders better understand data by providing summaries as well as context, such as how the data may be used in the permitting process and how it relates to regulatory benchmarks.

Produced by the
BBNC Land Department

Questions?
Call (800) 426-3602

The Permitting Process

Large development projects require multiple permits in order to move forward. The permitting process for the Pebble Mine project is complex, and requires over 60 permits, nine of which are directly related to hydrology.

The process will begin when the Pebble Limited Partnership (PLP) releases its final project description, its Environmental Baseline Document (EBD), and files a Section 404 Permit application with the US Army Corps of Engineers®. PLP CEO John Shively has said the partnership expects to begin permitting in late 2012, and anticipates that this process will take a minimum of three years.

The Pebble Watch science team developed a permitting matrix that provides details on permits for Pebble Mine, including links to relevant agencies and information on public comment periods (if any) for each permit. Permits are arranged by topic, so readers can easily pinpoint the main permits related to hydrology. Find the matrix under "Resources & Links" at www.pebblewatch.com.

Watershed Assessment

The U.S. Environmental Protection Agency (EPA) is conducting a year-long assessment of the Bristol Bay watershed, and it has posted an outline of the assessment plan on its web site. The assessment includes two rounds of public meetings, to begin in October 2011. Oral and written comments will be accepted. For more details, find the link to the assessment under "Resources & Links" at www.pebblewatch.com.

Coming up

Mining information sessions and community visits:

June 1 – EPA Bristol Bay Update Meeting, Newhalen Teen Center

June 2 – Mining information session, Newhalen Teen Center

June 2 - EPA Nushagak River Community Visits

June 3 – Mining information session, Dillingham BBNA Head Start Building

June 3 - EPA Bristol Bay Update Meeting, Dillingham Elementary School

For details, click on the calendar at www.pebblewatch.com.

Keep up to date on current events affecting the proposed project area:
www.pebblewatch.com