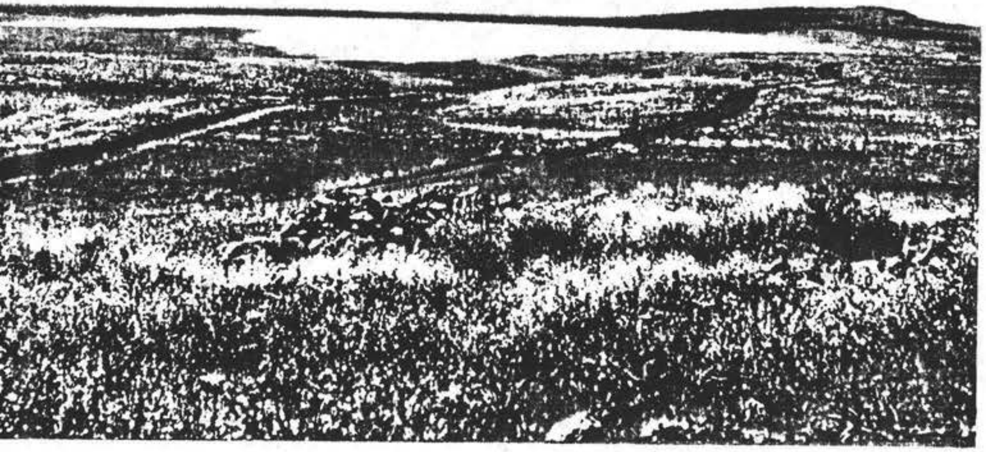
NATURAL STREAMS AND WATER RESERVOIRS ON THE GOLAN HEIGHTS: CAN THEY CO-EXIST?



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Among the first things that come to mind in connection with the Golan Heights, in northeastern Israel [N/P – 1/7] are the rivers and streams which characterize the area. Volcanic basalt rock strata with thin layers of clayey soil trapped between them, relatively abundant rain and snow (up to 1000 millimeters annually), and a dissected topography, combine to create a water-rich landscape that is one of Israel's most beautiful.

Since human settlement in the region is sparse, most of the Golan's water flows west along gullies and streambeds, to the Sea of Galilee's catchment basin. The Sea of Galilee [N-5/6] is Israel's largest water body, and supplies water for irrigation to most of the country, from Galilee to the Negev desert.

During the past decade, planners of water policy for agriculture in the Golan came to the conclusion that by storing the water on the Golan Heights the expense of pumping water up from the Sea of Galilee (210 meters below sea level) would be eliminated. This would be economically beneficial to farming on the Golan.

Work began on the first reservoir a short time after the first plan was drawn up. By the fall of 1984, there were dams in six of the main eleven catchment basins on the Golan.

Creating the reservoirs was quite easy, since the topography of the Golan's streams and the relatively low volume of alluvial material they bear make them suitable for the construction of "valley reservoirs". In these, the stream's water is trapped behind ramps of earth and stone laid across the streambed.

Some of the reservoirs were created upstream from areas designated as nature reserves. A water supply to the stream was then provided by a pipe which emerged from the lowest levels of the reservoir.

However, the construction of these reservoirs worried nature conservationists. How would the damming of catchment basins affect the downstream areas? It was feared that the cessation of the natural flow and its replacement by a water ration coming from the depths of the reservoir would lead to ecological changes. The existence of the Golan streams as unique landscape units and habitats for a wide range of plant and animal life was potentially threatened.

As there was no existing information on the subject, it was necessary to plan and carry out an original research program. In the fall of 1985, a series of studies began, aimed at gleaning data on the possible effect of the water reservoirs on the character and features of the Golan streams.

The Devash model

The effect of water reservoirs on the streams below them is far-reaching and complex. The lack of information from the pre-reservoir period added to the difficulties. Our first step, therefore, was to focus on a single stream which could function as a model to provide answers for specific queries.

The basalt rock streambed of Nahal Daliyyot [O-5], which was dammed by the Devash reservoir, was chosen as the model. It is a stream in which the water supply is trapped on higher ground, and a flow of water is supplied from the bottom of the reservoir. Nahal Gamla, just a few hundred meters from Nahal Daliyyot, is undammed. It was selected as control.

Five water sampling stations were chosen as sites for measurements, tests and experiments. Station No. 1 is in the upper, undisturbed section of Nahal Daliyyot. No. 2 was located near the pipe releasing water from the bottom of the reservoir; No. 3 and No. 4 were in Nahal Gamla, parallel to nos. 1 and 2. A comparison between these two pairs of stations illuminates the reservoir's influence on the stream. Station No. 5 was located lower down in Nahal Daliyyot, about 500 meters from No. 2; it provided data on the range of the reservoir's effect on the streambed.

Three tiers of data

During 1985-1987, monthly measurements and tests were carried out at each of the five stations. The data collected from these examinations may be divided into three tiers which reflect the ecological situation in Nahal Daliyyot and Nahal Gamla.

The first tier is *chemical-physical*. Field and laboratory data were collected on the physical conditions and chemical composition of the water. Among these data were temperature, electrical conductivity, turbidity, amount of suspended matter in the water, and the content of various elements and minerals. These factors come under the heading of "water quality" and directly affect the character and composition of plant and animal life in the water.

The second tier is *biological*. Invertebrates whose habitat is linked with the pebbles at the bottom of the stream are directly affected by water quality and the strength of flow, as well as the character of the streambed. Naturally, any change in these factors due to a reservoir upstream will affect these creatures.

The third tier is *ecological*. The first ecological parameter examined was primary production – determining the rate of production of organic material during photosynthesis. In order to measure the rate of primary production, glass cylinders were placed in the water at each of the stations. After the cylinders became covered with algae, they were removed from the water, and the amount of chlorophyll on each was measured.

The second ecological parameter measured was the decomposition rate of organic matter. The rate of decomposition was measured by placing bundles of dry cattail (*Typha angustata*)[1] leaves in the water for a period of four months. Every month, a portion of the bundles was taken out, dried and weighed. The rate of weight loss of the reed bundles represented the

1) *"soof"*.

rate of decomposition of organic matter in the streambed.

Physical results of damming streams: two-level reservoir

We found that during the summer, a layering phenomenon takes place in the reservoir, causing the formation of two "sub-reservoirs" one above the other. The upper layer of water is heated by the sun, and most of the biological and chemical processes (production of organic material and oxygen release) take place in this layer.

The water in the lower layer stays at a constant lower temperature; most of the biological and chemical processes taking place in it are linked with decomposition. As a result, the "lower reservoir" lacks oxygen, and collects nutritive and waste materials, some of which are toxic.

Since water for Nahal Daliyyot is released from the bottom of the reservoir, the stream is thus fed in summer by water of poor quality, with toxic materials and a low oxygen content.

The physical layering of the reservoir also affects the water's temperature. The water temperature in Nahal Daliyyot and Nahal Gamla changes in the course of 24 hours, paralleling changes in air temperature. The average summer range of temperature, between maximum daytime temperature and minimum nighttime temperature, is about 15 degrees Centigrade.

However, due to the layering effect in the reservoir's water, the water supplied to the stream has a temperature range of only 2 degrees Centigrade. At Station No. 5, the minimum and maximum temperature ranges resembled those at No. 2. Thus, the temperature effect of the reservoir's water is still felt at least 500 meters downstream from the pipe.

Changes in water temperature may have a direct effect on the invertebrates in the stream. Since their biological activity depends on ambient temperature, the composition of the population varies with temperature changes. A narrower temperature range of the water released from the reservoir leads to the selection of animals preferring such a temperature range. In the section of the stream entering the reservoir, on the other hand, there are animal species which prefer a wider temperature range.

The layering of the water also has an effect on the suspended solids. Material suspended in the water reduces water clarity, but the suspend solids include organic matter which provides nutrition for many animal species. The organic particles are especially important in a flowing stream, since they are thus easily transported from one place to another.

Significant differences were found in turbidity and amount of suspended material between the stations at the entrance to the reservoir (No. 1), at the exit (No. 2), and downstream (No. 5). During the summer, turbidity increased in the natural streambed of Nahal Gamla as a result of greater amounts of suspended matter.

In the same season, water turbidity at the exit from the reservoir decreased, the result of a ten-fold decline in the amount of suspended matter. Water turbidity continued to be low, 500 meters downstream from the reservoir. Thus, the reservoir serves as a settling basin for particles which will not reach the lower reaches of the streambed. Such a change is bound to affect the aquatic organisms dependent upon the organic particles in the suspension.

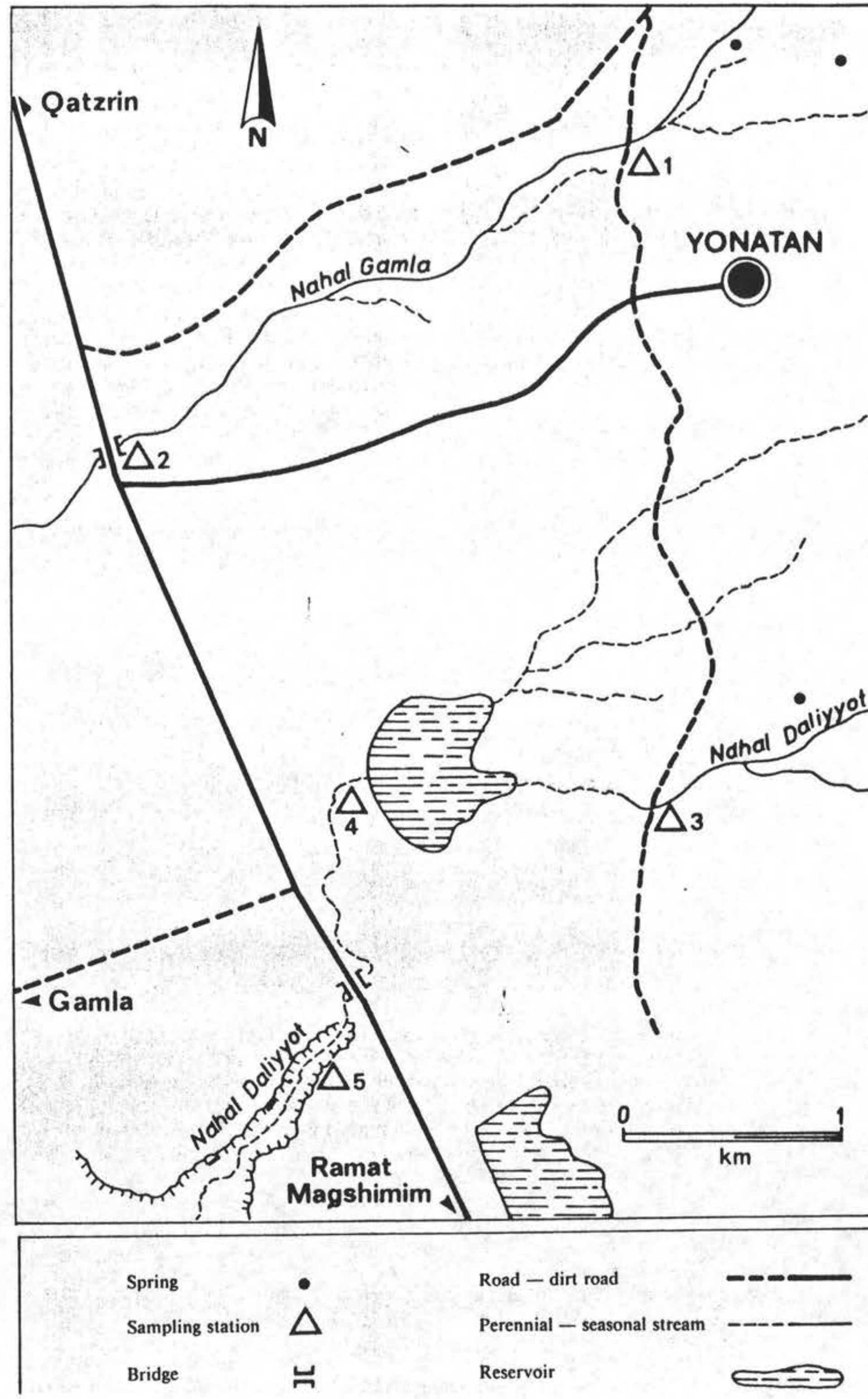
Biological effects of damming

Invertebrate species living on the pebble bed of the stream were collected on artificial pebble bases which were submerged in the stream throughout the period of research. Two main groups of fauna were identified.

1) A group typical of the stream entering the Devash reservoir and Nahal Gamla – the control area. This included *Melanopsis* spp. pond snails[2]; insect larvae of the Trichoptera family[3] and of the genus *Hydropsyche*, as well as beetle larvae.

2) A group typical of the stream below the reservoir. This included *Ostracoda*[4] and Isopoda[5] shrimps, larvae of mosquitos

2) *"shahrir ha-nehalim"*; 3) *"se'irei kanaf"*; 4) *"tsid-fonit"*; 5) *"shevei raglayim"*;



The inflow of Nahal Daliyyot (Koby Tuch)

of the Simuliidae family[6], and various species of leeches[7].

Each group represents an accommodation to conditions with different rates of flow, nutrition supply, type of streambed, and resistance to changes in the water temperature range. The distribution tendency of fauna groups revealed animals adapted to life in oxygen-rich, strongly flowing water over a pebble bed in the streams entering the Devash reservoir and Nahal Gamla. The stream below the reservoir's exit, on the other hand, contained fauna suited to a weak water flow and a soft base of sand and silt.

Ecological results

The amount of algae which grew over the glass cylinders in the streambed below the reservoir in summer was, on the average, a hundred times the amount on the cylinders above the reservoir. This indicates an extreme enhancement of the production of primary organic matter, influenced by the reservoir.

The rate of decomposition of reed leaves differed at the entrance to the reservoir and at the exit. After 118 days of submersion, all the reed leaves at the entrance to the reservoir were decomposed. At the exit, however, about half the amount of the leaves remained.

The daily rate of decomposition at the height of the process was 0.95 percent at the entrance to the reservoir, and 0.50 percent at the exit. This indicates a significant decline in the biological activity of decomposing organic matter in the section of the stream below the Devash reservoir.

6) *"simuliyot"*; 7) *"aluqot"*.

Safeguarding the streams

The effect of the Devash reservoir on Nahal Daliyyot can serve as a model for the effect of other reservoirs on Golan streams. The study indicates changes which occur downstream in Nahal Daliyyot due to the presence of the reservoir in the middle of the drainage basin.

Changes occurred in three of the stream's characteristics: water quality, composition and abundance of invertebrates which live on the pebble bed, and ecological functioning.

Most changes in water quality are temporary, and occur during the "layering" season in the reservoir. They vanish when the reservoir is empty, or unlayered; yet they are enough to cause long-lasting changes in the biological and ecological conditions of the stream.

Unlike chemical and physical changes, biological and ecological changes have a cumulative effect. In the long range, the changes may become irreversible.

The significance of the changes observed thus far is not fully clear. It is difficult to distinguish between the various complex biological and ecological factors involved, and to predict the long-range damage to streams. It is therefore important, at this stage, to safeguard existing stream systems.

The simplest way to rehabilitate the Golan streams below the reservoirs – without affecting the needs of farmers, or destroying the reservoirs – is to direct a "natural water flow" down the entire length of the streambed. This can be done by cutting a channel in a detour around the entrance to the reservoir, directly to the stream below the reservoir. The expense involved is a low price indeed to pay for the continued existence of these unique habitats and lovely scenic areas in the harsh basalt landscape of the Golan. □

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