Galleries and Their Use for Development of Shallow Ground-Water Supplies, with Special Reference to Alaska

By ALVIN J. FEULNER

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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DEFINITION OF TERMS

The following terms used in this report are defined, and the source of definition is given, if known.

Aquifer—a formation, group of formations, or part of a formation that is water-bearing. (Meinzer, 1923, p. 30.)

Drainage system—consists of a surface stream or body of impounded surface water, together with all surface streams and bodies of impounded surface water that are tributary to it. An artificial drainage system is generally understood to include also the conduits that have been installed below the surface. (Meinzer, 1923, p. 15.)

French drain—a drain consisting of an underground passage made by filling a trench with loose stones and covering with earth—called also a rubble drain. (G. & C. Merriam's dictionary, 1961, p. 908.)

Gallery—an artificial chamber provided for the collection of groundwater. (G. & C. Merriam's Dictionary, 1961, p. 930.)

Infiltration gallery—an artificial tunnel which extends into the zone of saturation and through which water flows by gravity from the zone of saturation to the land surface or into a sump or well. (Meinzer, 1923, p. 60.)

Permafrost—permanently frozen ground; a thickness of soil or other superficial deposit or even or bedrock, at variable depth beneath the surface of the earth, in which a temperature below freezing has existed continually for a long time (from 2 years to tens of thousands of years). (Muller, 1947, p. 3.)

Continuous permafrost—permafrost at a depth of 30 to 50 feet in which temperature is generally below—5° C. (Black, 1954, p. 843.)

Discontinuous permafrost—permafrost at a depth of 30 to 50 feet in which temperature is generally −1° C to −5° C. (Black, 1954, p. 843.)

Sporadic permafrost—permafrost at a depth of 30 to 50 feet in which temperature is generally above −1° C. (Black, 1954, p. 843.)

Well—classified with respect to the method of sinking, as:

- **bored**—a well that is excavated by means of a hand or power auger, the material being brought up, for the most part, by the auger. (Meinzer, 1923, p. 63.)
- **drilled**—a well that is excavated wholly or in part by means of a drill, either percussion or rotary, which operates either by cutting or by abrasion, and in which the materials are brought up by means of a bailer, sand pump, or hollow drill tool, or by a self-cleaning method. (Meinzer, 1923, p. 63–64.)
- **driven**—one constructed by driving a casing at the end of which there is a drive point, without the aid of any drilling, boring, or jetting device. (Meinzer, 1923, p. 64.)
- **dug**—one that is excavated by means of picks, shovels, and spades, or by means of a steam shovel or other dredging or trenching machinery. (Meinzer, 1923, p. 63.)
- **jetted**—a well constructed by pumping water through a pipe of relatively small diameter and forcing the water downward through the drill bit against the bottom of the hole. The stream of water loosens the material and the finer grained

material is carried upward and out of the hole. During drilling, the drill pipe is turned slowly to insure a straight hole.

Zone of saturation—the zone in which the functional permeable rocks are saturated with water under hydrostatic pressure. (Meinzer, 1923, p. 21.) In sinking a well it is considered that the zone of saturation is reached at the point where water first enters the well. This water is ground water. (Meinzer, 1923, p. 22.)

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

GALLERIES AND THEIR USE FOR DEVELOPMENT OF SHALLOW GROUND-WATER SUPPLIES, WITH SPECIAL REFERENCE TO ALASKA

By Alvin J. Feulner

ABSTRACT

In many areas in Alaska galleries are the only economical or feasible means of obtaining an adequate supply of water throughout the year. Galleries used in Alaska include French drains, lateral galleries, vertical galleries, and bedrock galleries. The type of gallery, method of installation, and amount of maintenance required depend on local geologic and hydrologic conditions which must be examined thoroughly before installation is attempted.

The French drain, a primitive form of the gallery, is merely a drainage trench filled with rubble with a sump at one end from which the water may be pumped.

A lateral gallery includes a sump with a lateral pipe, or several pipes which extend into the water-bearing zone to increase the flow of water to the sump. The design of the lateral galleries may be varied to meet local conditions.

Vertical galleries consist of a group or battery of vertical pipes arranged around a central pipe, which is used as a well, and placed in a large-diameter dug well. The battery of pipes surrounding the central pipe slows the movement of highly turbid water entering the well and allows the fine material to settle out before water is pumped.

A bedrock gallery is a tunnel or adit driven into consolidated rock to intercept water-bearing zones such as fractures and faults. A shaft in which to collect and store the water is generally constructed at the inner end of the tunnel or beside it. Offset drilling into seepage zones may be needed to increase the flow of water.

Galleries in Alaska have been installed at Air Force installations north of the Arctic Circle as well as southward to, and along the length of the Aleutian Islands. Such installations, properly maintained and heated, have proven highly successful during the past 10 years. For individuals in some rural areas, as well as certain villages and towns in Alaska, gallery installations might be the best or only means of providing a year-round water supply.

INTRODUCTION

The word "gallery," when used as a hydrologic or engineering term, is defined in G. & C. Merriam's dictionary (1961, p. 930) as an "artificial chamber provided for the collection of groundwater." Water-collection galleries have been used since earliest times as a means of developing water supplies. The advent of improved drilling techniques and reduction of the danger of pollution by use of drilled, cased wells in recent years, have directed emphasis toward ground-water development by wells. However, under certain geologic and hydrologic conditions galleries are superior to wells. For example, in areas where water-bearing surficial deposits, underlain by impermeable bedrock or permafrost of great thickness, are thin or discontinuous, a gallery may be the only way of obtaining a water supply. Where surficial deposits are absent bedrock galleries may be used to tap fault zones or other water-bearing fractures in the bedrock.

Properly constructed galleries have several advantages over surface-water supplies because the filtering action of material overlying the gallery lowers turbidity and lessens the liklihood of contamination, and because galleries are not as likely to freeze in winter. Furthermore, the cost of maintaining a gallery may be appreciably less than maintaining a surface water intake.

Many gallery designs are used because of differences in local geologic conditions, but three general types are constructed in unconsolidated materials. These include the French drain, the lateral gallery, and the vertical gallery. Each of these types, and various combinations of them, can be used to provide water where conventional wells are unsuccessful or are too costly to construct and maintain.

Galleries in Alaska have been constructed in regions of continuous permafrost, discontinuous permafrost, sporadic permafrost and no permafrost. As shown by figure 1, much of Alaska is included in the regions of continuous and discontinuous permafrost. Galleries constructed in these regions generally need to be heated to prevent freezing of the installation and piping. In the regions of sporadic or no permafrost, galleries generally need not be heated.

About 90 percent of the known galleries in Alaska has been installed at Air Force stations and all but two of these galleries are presently (1962) in operation. These galleries have provided water to meet requirements throughout the entire year for periods ranging from 1 to 10 years. Some galleries have been inoperable for short periods, but in each gallery the trouble was caused by failure of mechanical equipment or human error, rather than by failure of the gallery itself.

Because of their rather high cost and limited use, only one bedrock gallery is known to have been installed in Alaska. The discussion of bedrock galleries is therefore brief.

During the period in which the U.S. Geological Survey has been engaged in a program of providing technical assistance regarding water supplies at U.S. Air Force installations in Alaska, many changes

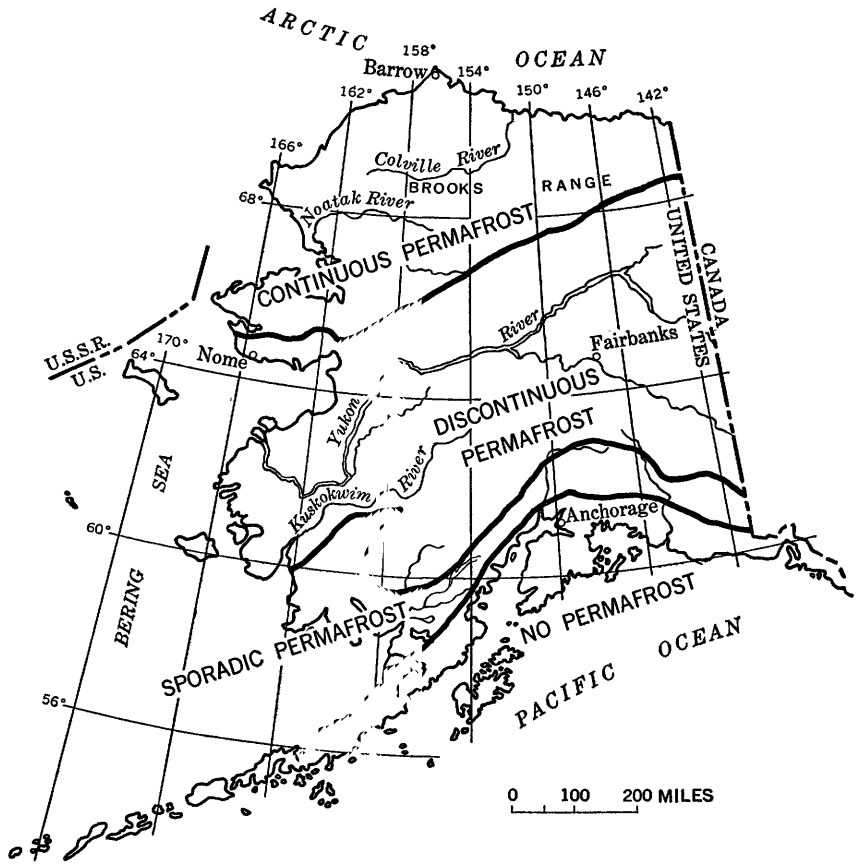

FIGURE 1.—Sketch map of Alaska showing general distribution of permafrost areas. (Adapted from Hopkins, Karlstrom, and others, 1955.)

have been made in basic gallery design, as well as in the use, construction, and maintenance of galleries. This paper describes use, construction, and maintenance of galleries as an aid in obtaining groundwater supplies in Alaska. The applications and principles in this paper, however, apply to many areas and almost any climatic condition. The work on this report was accomplished as a part of the U.S. Geological Survey program with the U.S. Air Force, Alaskan Air Command.

TYPES OF GALLERIES AND THEIR INSTALLATION

FRENCH DRAINS

The French drain is a rubble-filled trench used to channel the underground flow of water to or away from any specific area. This drain, when combined with a sump, is a primitive type of gallery. The

French drain may be used to channel flows of underground water toward a lateral or vertical gallery to increase the amount of water available.

French drains may be particularly useful in areas underlain by clay, shale, or other impermeable material as a means of channeling water from a lake or stream to a point from which it can be pumped conveniently. Figure 2 shows an idealized condition in which a French drain is used to carry water from a lake, underlain by impermeable clay, to a sump from which the water is taken for use.

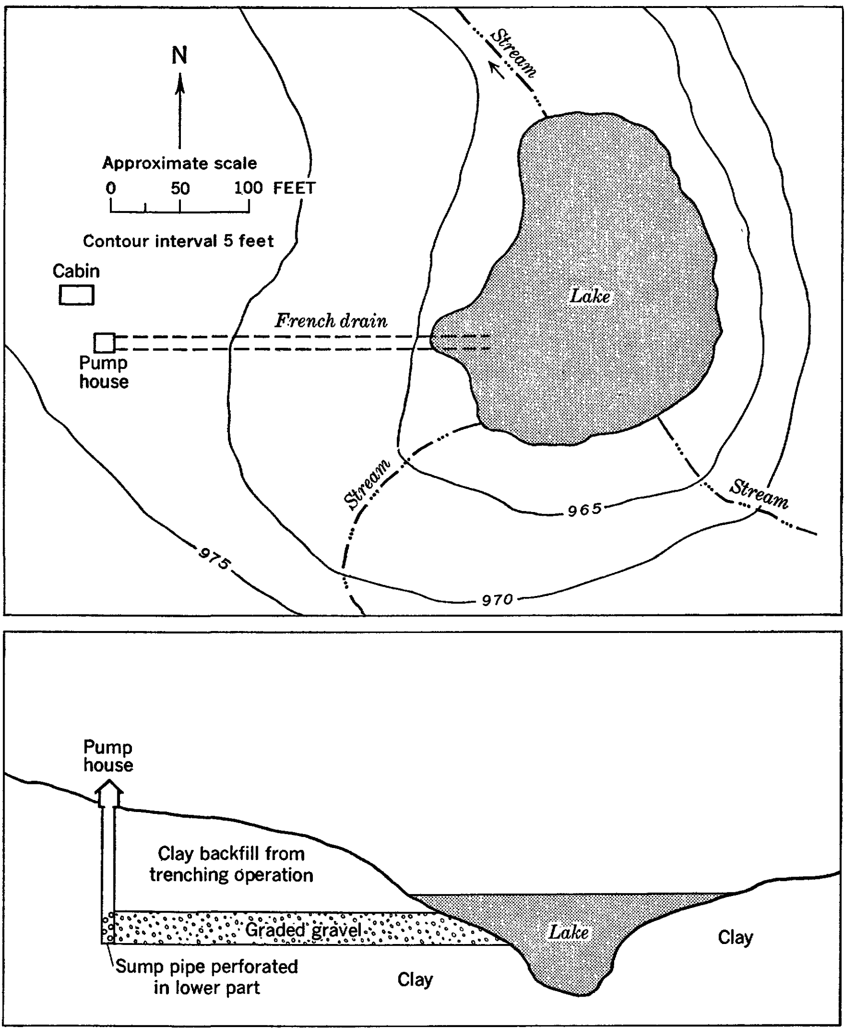

FIGURE 2.—Sketch map of French drain installation and diagrammatic section showing material and backfilling.

French drains may provide water of lower turbidity and bacterial content than a direct surface-water source. However, as an added sanitary precaution, water derived from surface-water sources should be chlorinated before use, even though the water may be filtered through sand and gravel in the drain prior to being pumped.

Installation of a French drain requires little material besides gravel or rubble. Because gravel is widely available, it is commonly used for installation of French drains in Alaska. Apart from the cost of materials, most of the installation cost of a French drain is for trenching and backfilling.

Construction consists of digging a ditch to the zone of saturation, filling the lower part of the ditch with graded rock, and filling the upper part of the ditch with the excavated material. The ground surface is cleared of material excavated from the trench, and the area is resodded or reseeded to retard infiltration of silt and to prevent surface runoff from entering the drain.

LATERAL GALLERIES

Lateral galleries have many applications and a wide variety of designs. A gallery to fit specific geologic and hydrologic requirements of a site may, however, require modifications from any type previously constructed. Lateral galleries are called infiltration galleries if they extend into the zone of saturation. Infiltration galleries may consist of a sump with a single small lateral pipe leading from the sump to an aquifer below a streambed or they may be elaborate systems with two or more banks of laterals radiating from the sump and placed at different levels in the aquifer or aquifers.

Lateral galleries are generally less than 40 feet deep because installation of the lateral pipes at greater depths is difficult and costly. A method of jacking laterals into place from sumps deeper than 40 feet has been developed, and although special equipment is required, laterals have been successfully placed at depths greater than 200 feet (Kazmann, 1948). Because this special type of lateral gallery is designed for producing large amounts of water, its greater cost is justified.

Figure 3 shows a typical lateral gallery installation under a streambed which has one lateral extending out from the sump. The length of laterals in Alaska generally ranges from 25 to 500 feet, depending upon the extent of the intake area and the amount of water desired. The laterals are constructed of pipe, usually corrugated iron or tile, ranging in diameter from 18 inches to 4 feet. Any number of laterals may be added in different directions or at different levels to increase the volume of water flowing into the lateral. In some areas it may

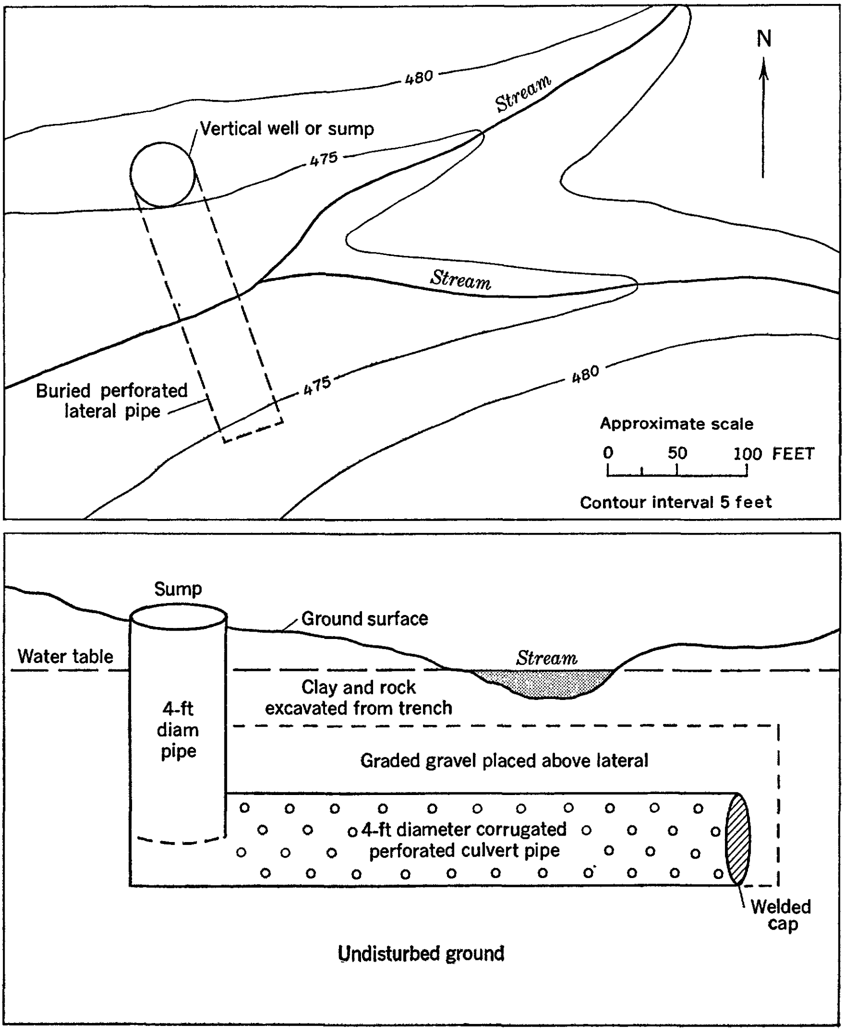

FIGURE 3.—Sketch map of lateral gallery installation and diagrammatic section showing material and backfilling.

be desirable to add French drains at several points along a lateral to increase the amount of inflow.

Prior to construction of a lateral gallery system consideration should be given to the length of time that the system is to be used and to the required volume of water. The life of the system is largely controlled by the type of materials used for the laterals. Materials which give the longest life include vitrified clay, brick, concrete, and cast iron (Todd, 1959, p. 146). Materials commonly used in Alaska include transite pipe, wood-stave pipe, and corrugated-steel culvert. The required rate of waterflow determines the length, diameter, and number of laterals and the size of perforations cut in the pipe.

Where a perennial stream is present, laterals may be laid out parallel to the stream to induce infiltration into the gallery from the stream. In an area where there is no perennial stream, water may be present at shallow depths in water courses which flow only during the summer months. Installation of a lateral across such a water course may provide water throughout the year. Where several layers of permeable sand or gravel separated by clay are present, laterals might be installed into each aquifer to obtain a greater amount of water.

Trenches for lateral galleries are commonly excavated 4 to 6 feet below the top of the zone of saturation, or below the level at which the top of the zone will be when water levels are lowest. The trench is backfilled with about a foot of graded rock and the laterals are placed on the fill that slopes slightly toward the sump. Graded rock or gravel should cover the laterals completely and should extend upward to or above the point of the highest ground-water level during the year in order to take advantage of maximum infiltration. Pea-size or slightly coarser gravel, relatively free of fine-grained materials, allows water to move rapidly through the fill and prevents plugging of the perforations in the lateral. Material excavated from the trench is commonly used to complete filling the trench. Excess material remaining from the trenching operation should be removed from the area, and a cover of grass, tundra, or other native vegetation will prevent silt and clay from washing into and plugging the fill.

VERTICAL GALLERIES

A vertical gallery consists of a group, or cluster, of perforated vertical pipes surrounding a central pipe placed in a large-diameter dug well. The central pipe extends upward to or above the ground surface and is used as the well. The additional pipes surrounding the central pipe reduce the velocity of water entering the system and permit silt and fine sand to settle out of suspension before entering the central pipe. Figure 4 shows an idealized vertical gallery installation and the top and side view of the pipe cluster. Vertical galleries are best suited for locations along streams where the water is turbid and where the zone of saturation is near the ground surface. Vertical galleries may be connected to the stream by means of French drains.

Vertical galleries are usually installed only where large amounts of water are available. The size of the pipe cluster is determined by the required amount of water. Generally, however, an excavation 20 feet in diameter is large enough for most vertical galleries. The depth of excavation depends upon local conditions but is generally 20 to 25 feet.

Pipes are arranged in a cluster as shown in figure 4. The pipes surrounding the central pipe are cut off and capped both at the top and bottom. Usually, the entire cluster is put together before it is placed in the excavation; thus, placement can be made with the same equipment used to dig the pit. After placing the pipes vertically in the

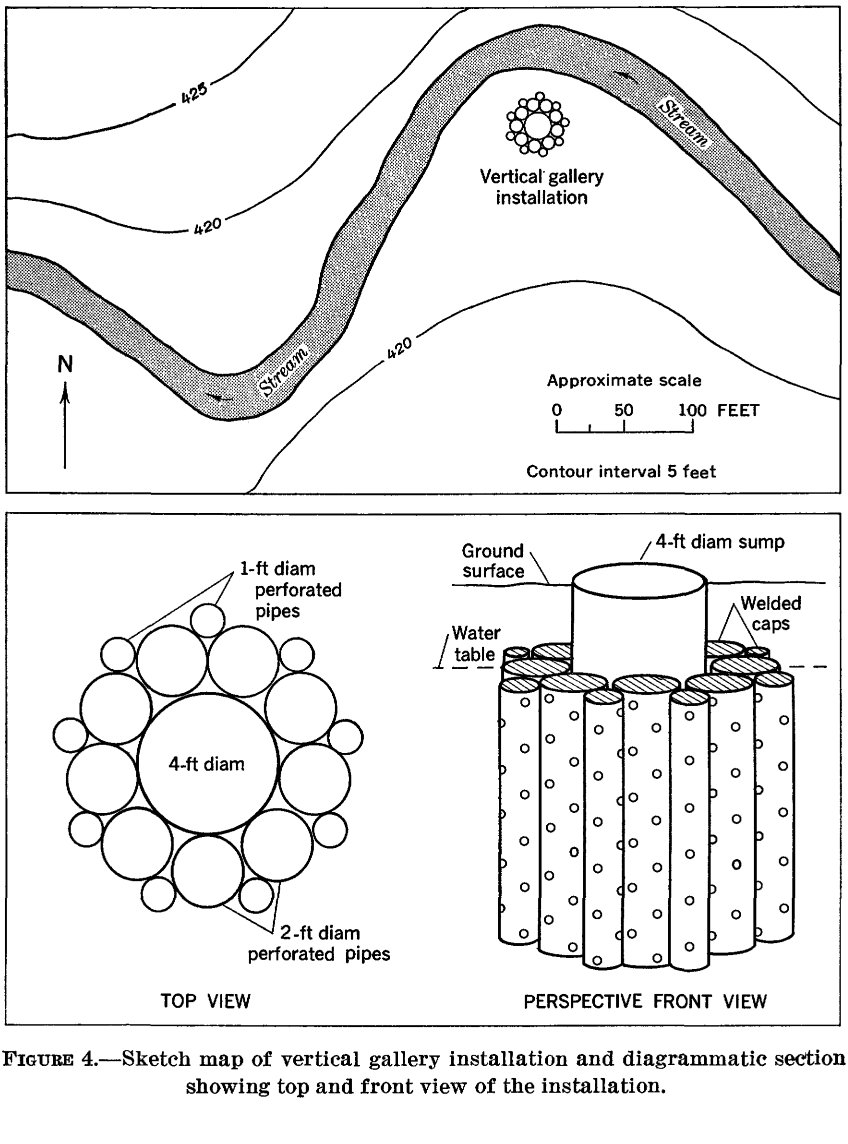

FIGURE 4.—Sketch map of vertical gallery installation and diagrammatic section showing top and front view of the installation.

pit, the area surrounding the pipe cluster is backfilled with graded rock material to the maximum level at which ground water will stand during the year. The upper part of the pit is then refilled with the excavated material, and vegetation is replaced around the installation.

Installations of the type shown in figure 4 can be very successful when located near a perennial stream and in some areas might be used as a source for irrigation, mining, or small manufacturing.

BEDROCK GALLERIES

Bedrock galleries are a special type of installation consisting of a tunnel or adit driven into bedrock to intercept faults, fractures, or other water-yielding zones. For example, the University of Alaska at College obtained a water supply by driving a tunnel into bedrock to reach water-bearing fractures. At several places along and at the end of the tunnel, shafts were sunk to a depth of 30 to 50 feet, and the bottoms of these shafts were enlarged to increase the infiltration rate and water-storage capacity. In one of the shafts, diamond-drill holes were bored into fractures to increase the intake area of the fractures.

Bedrock galleries may be installed where permafrost exists. At such places, water could be stored in the bedrock shafts which are not susceptible to differential thawing as are outside storage tanks which require heating.

The method of installation of a bedrock gallery depends on the type of rock and its porosity, permeability, and fracture pattern and on the position of the water table. To construct a bedrock gallery which provides the required amount of water, an adit or tunnel is driven into the rock until sufficient fractures or other water-bearing zones have been intercepted. Water entering the tunnel may be collected in a sump, usually constructed by driving a shaft vertically from the floor or to one side of the tunnel. Several shafts, or sumps, may be sunk from one long tunnel to increase the amount of available storage. The bottoms of the sumps can be enlarged to increase the intake area and to act as storage tanks. In some areas it may be desirable to drill holes into the water-bearing zones to increase the rate of flow into the storage shafts.

GALLERY MAINTENANCE

Maintenance of galleries is perhaps as important as proper construction if maximum usefulness and gallery life are to be obtained. Lateral galleries require more maintenance than either vertical galleries or French drains. Bedrock galleries require only a minimum of maintenance. Maintenance procedures include periodic cleaning and prevention of silting and freezing.

CLEANING

Water entering any kind of gallery generally contains some sediment which is deposited in the gallery and which should be removed from time to time. In lateral galleries maintenance manholes are usually placed every few hundred feet along each lateral. These manholes provide a means of washing any accumulated sediment down into the sump where it can be easily removed. The manholes also provide a means of determining if the pipe has collapsed or been damaged.

French drains and vertical galleries cannot be cleaned. The French drains do not usually become plugged with silt except near the intake of water at the stream or lake. It is usually more economical to excavate the silt from the drain and to refill the drain with clean gravel than to clean the drain. Vertical galleries generally have a short operating life which depends upon the turbidity of the water entering the gallery. If a vertical gallery becomes plugged with silt, it may be more economical to install a new system rather than to renovate the old one.

PREVENTION OF FREEZING

Most galleries installed in areas of continuous and discontinuous permafrost either are heated by one or more steam lines or by electrical heating cables. The heating system is installed during gallery construction and must be adequate to prevent complete freezing of the gallery and the immediate surrounding area. The usual procedure in installing steam lines is to place one steam line on the upper surface of the gallery lateral and a second about 4 to 6 feet above the lateral. In areas of less frost penetration, only the lower line is commonly installed. Usually, the pumphouse and sump are also heated.

Snow is an excellent insulator and can be used to prevent freezing of the gallery during the cold winter months. To insure an adequate blanket of snow over the installation, snow fences are placed transverse to the prevailing wind. The fence traps the snow and prevents it from blowing away. A blanket of snow 3 or 4 feet thick inhibits freezing of the ground and permits a freer movement of ground water into the gallery. In addition to its insulating effect, a cover of snow will provide a source of recharge to installations where two steam lines are used. In such installations, the upper steam line keeps the ground thawed and melts part of the snow cover. The water thus formed seeps down through the soil and into the gallery.

To preserve the snow cover in the vicinity of the gallery, the area should be kept free of traffic. Vehicle tracks or even footprints break the snow cover and allow deep penetration of the seasonal frost which could divert ground water away from the gallery. At one installation a gallery became dry because an ice dam, formed by deep frost penetration where traffic crossed the gallery lateral, diverted the normal movement of water. To eliminate such occurrences, the areas surrounding the gallery, particularly those upgradient, may be fenced. Fencing not only prohibits traffic from crossing the area, but also lessens the possibility of contamination.

In areas of both continuous and discontinuous permafrost, pumping of the galleries is controlled in order to maintain a steady flow of water to the galleries during the winter months. Because normal daily use ranges from 5 to 10 gpm (gallons per minute) and because the normal rate of intermittent pumping ranges from 35 to 50 gpm, a reduction in the rate of pumpage is necessary to maintain a continuous flow through the system. Pumping rates are cut to approximately one-half the summer rate at about mid-October and a further reduction to about 5 to 10 gpm usually is made at about mid-December. The lowered pumping rate is continued through the following April. After April, recharge from melting snow provides sufficient flow to prevent the gallery from freezing.

GALLERY USE IN ALASKA

In Alaska galleries have been utilized by the U.S. Air Force at many of their remote stations largely because these stations are not located near perennial surface-water sources. Gallery construction has proved to be a very satisfactory method, and the only method at some sites, of providing year-round water supplies. Economics has played a major part in stimulating the construction and use of galleries. As most remote stations can be reached only by air, transportation of a drill rig is both difficult and expensive. In most places a gallery can be constructed with local equipment and labor.

Prior to 1950 the city of Anchorage obtained its water supply from a lateral gallery extending along Ship Creek, approximately 1 mile upstream from Cook Inlet. The Alaska Railroad also operated a similar gallery on the opposite bank of the stream for its own water supply. Each gallery was intended to produce 5 mgd (million gallons per day). Both galleries were placed on a standby basis in 1950 to be used as emergency supplies for the city of Anchorage until other sources were developed, but one has since been abandoned.

In 1950 a power plant in Fairbanks reportedly obtained part of its water supply from a gallery driven under the Chena River by the

Northern Commercial Co. (Cederstrom, 1950, p. 27). This gallery is of interest because, according to C. G. Lincoln (oral commun., 1962) formerly of the Northern Commercial Co., it was dug under the river by allowing the gravel deposits to freeze prior to excavation. This freezing formed a wall of frozen gravel which surrounded the excavation and kept ground water out. Upon completion of the lateral tunnel, a charge of explosives was placed at the end of the tunnel under the river and the remaining part of the tunnel was filled with coarse gravel. The ensuing detonation allowed the gravel-filled tunnel to fill with water from the river. The structure thus formed could probably be considered as an elaborate type of French drain.

As previously stated, the University of Alaska has utilized a bedrock gallery for many years to obtain a water supply.

Several mining camps in Alaska constructed galleries to obtain utility and potable water, but little data are available on the number of gallery units or on the amount of water produced. A gallery at the Suntrana Mine at Healy has been in operation since 1925, and a gallery at the Usibelli Coal Mine has been in operation since 1952 (L. H. Saarela, oral commun., 1962).

In 1955 a vertical caisson filled with gravel and a buried lateral conduit leading to the river were constructed near the edge of a side channel of the Yukon River at Fort Yukon to obtain water for a school. Because of stripping of the natural vegetation around the area this installation reportedly was partially washed out and plugged with silt during floods in 1959 and has therefore been abandoned since that time.

Galleries were installed at 14 military installations in Alaska during 1951–61, and all except two of these installations are still operating. One failure resulted when the electrical heating cable, used to supply heat to the gallery, broke during the winter and the gallery froze. A second failure was a result of gradual thawing of permafrost under the gallery installation, a condition which permitted water to pass below the gallery. The water supply was restored by installing a second gallery at greater depth.

AREAS OF CONTINUOUS AND DISCONTINUOUS PERMAFROST

Galleries in areas of continuous permafrost, except at sites near large lakes or rivers, are the only practical method of obtaining year-round water supplies. The thickness of permafrost, which ranges from 1 foot to as much as 1,300 feet, and the poor chemical quality (generally high iron or chloride content) of water obtained from beneath permafrost make the use of wells impossible or uneconomical in most areas of continuous permafrost. Wells drilled in areas of discontinuous permafrost, however, may provide potable water if a sufficient thickness of unfrozen saturated material is present above, within, or below the frozen zone. In some areas of discontinuous permafrost, where saturated sands and gravels are thin and the underlying rock is impermeable, lateral galleries may provide more water than drilled, dug, jetted, bored, or driven wells.

In one area in the continuous permafrost zone north of the Arctic Circle, a gallery was installed across a stream valley to intercept ground water flowing in a thawed zone between permafrost and the zone of seasonal frost. A gallery lateral was placed in a trench about 4 to 6 feet deep in the permafrost underlying the valley. Corrugated-steel culvert pipe 4 feet in diameter was used as the lateral pipe, and a sump, also of culvert pipe 4 feet in diameter, was constructed at one end. The gallery and adjacent ground area are heated by two steam lines, 2 inches in diameter. One steam line extends along the top of the gallery lateral and the other is 6 feet higher. This gallery, combined with a heated aboveground storage tank, provides a year-round supply of water for the station.

Another gallery, installed across the valley of a small perennial stream at a station in the discontinuous permafrost zone slightly south of the Arctic Circle, is placed in gravel which is unfrozen to a depth greater than 20 feet. The gallery is placed across the valley so that both ends are in permafrost, but the area under the center of the gallery lateral is free of permafrost. This gallery is also constructed of perforated corrugated-steel culvert pipe, 4 feet in diameter, and is heated by one electric heating cable placed on the upper surface of the gallery lateral. The gallery installation and an aboveground storage tank provide a year-round water supply for the station.

Gallery installations have also been constructed where no streams exist. In one area, in the permafrost zone near the Arctic Circle, a perforated corrugated-steel culvert pipe, 2 feet in diameter, was installed to intercept ground water moving along a fault zone. The gallery transmits the water from the point of interception to a sump from which the water is pumped for use. Installation of the gallery required dynamiting more than 300 lineal feet of frozen bedrock and removing material to a depth of 10 to 12 feet. The gallery is heated along its entire length by means of two steam lines, 1½ inches in diameter. One steam line is placed on the surface of the gallery lateral pipe and the other is buried in the overlying fill about 4 feet higher. This installation is successful in providing a year-round water supply for the station.

Several Air Force stations in areas of continuous, discontinuous, sporadic, and no permafrost have galleries, usually lateral galleries, connected to reservoirs of shallow lakes. Galleries are placed either beneath or adjacent to the reservoir or lake. This method of installation serves two purposes: reduces the likelihood of contamination and provides a supply of water even when the reservoir or lake is completely frozen. Because of the insulating effect of the overlying body of ice and its snow cover, the sand and gravel underlying the reservoir generally remain unfrozen. Where sand and gravel deposits are permeable, adequate supplies of ground water may be obtained. Water impounded in reservoirs is sometimes lost by seepage as soon as severe winter weather prevents further inflow. Under such conditions a gallery installed in the gravel deposits beneath or slightly downgradient from the reservoir may be the best means of salvaging the seepage and maintaining a year-round water supply.

AREAS OF SPORADIC OR NO PERMAFROST

Gallery installations in areas of sporadic or no permafrost in Alaska are very similar to those installed in areas of continuous or discontinuous permafrost. Generally, however, the installation in areas of sporadic or no permafrost does not require heating unless the aquifers feeding the gallery are within the depth range of seasonal frost.

Even though surface-water supplies are more widely used in regions of sporadic or no permafrost than in other permafrost regions, the depth of freezing in shallow lakes or reservoirs is great and thus prohibits the use of these supplies during the winter months. Under such freezing conditions, galleries installed under the lake or reservoir can still supply water. Even if the lake or reservoir is frozen to the bottom, the underlying aquifers may remain unfrozen and thus supply water to the gallery.

Lateral galleries are constructed along and across stream valleys as in other permafrost areas, and in some areas galleries are installed where there is no flow of surface water throughout much of the year. One such installation in the Aleutian Islands consists of four laterals extending along the channels of two intermittent streams. The water collected by these laterals is piped into a central sump and passes from this sump downslope into a second sump from which the water is pumped for use. Although no flow of water appears at the ground surface, the gallery collects more than 200 gpm.

At another site in western Alaska, a gallery was installed in an area where no definite drainage exists. At this site extensive digging of test pits and test drilling were required to determine the lowest elevation at which ground water flowed in the underlying impermeable material. When such an elevation was determined, a gallery was constructed by excavating 8 to 10 feet of rubble and broken rock material and 6 to 8 feet of impermeable bedrock. The gallery was then placed in the trench and was backfilled with graded rock to within 4 feet of the ground surface. The remaining 4 feet was filled with excavated material from the trench. The trench acts as a sump to collect water and to provide a sufficient head for the pump to operate during periods when the amount of water flowing over the subjacent bedrock is 1 foot or less in depth.

CONCLUSIONS

Galleries have not been fully utilized in Alaska partly because of a lack of knowledge of gallery construction, especially under subarctic and arctic conditions, and partly because of the belief that shallow ground-water supplies usually are contaminated. The lack of knowledge of how to protect galleries from freezing during winter months probably has also been a deterent. Observation has shown, however, that under certain geologic and hydrologic conditions properly installed and maintained galleries are a relatively reliable means of supplying moderate to large amounts of water throughout the year.

Galleries, either alone or supplemented by French drains, have been highly successful at Air Force stations in Alaska. They have been used to induce infiltration of water from streambeds, to divert water from fault zones, to tap water confined between seasonally frozen ground and permafrost, and to obtain low-turbidity water reasonably constant in chemical quality from beneath streams, lakes, and reservoirs.

For the small water user in areas where no heat is required, gallery installations may provide a rather low-cost method of obtaining a year-round water supply. For larger supplies, a gallery may also provide the most economical method of obtaining water.

Most outlying villages and some larger cities in Alaska are along rivers where annual flooding and silt-laden waters are serious obstacles to utilization of a surface-water supply. Also, at such areas drilled wells may be impractical to construct and maintain because of transportation costs. Therefore, vertical or lateral galleries may be the best means of obtaining a water supply because local labor and equipment can be used to reduce construction costs and to control excessive turbidity. The chance of failure by freezing is almost eliminated if proper maintenance procedures are followed.

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