CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 322

GROUND-WATER RESOURCES OF SURREY MUNICIPALITY BRITISH COLUMBIA

By

J. E. Armstrong and W. L. Brown

OTTAWA

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CONTENTS

Page

CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV

CHAPTER V

CHAPTER VI

ILLUSTRATIONS

GROUND-WATER RESOURCES OF SURREY MUNICIPALITY, BRITISH COLUMBIA

CHAPTER I

INTRODUCTION

GENERAL STATEMENT

This report deals with ground-water conditions of Surrey Municipality in the province of British Columbia investigated by the Geological Survey of Canada during the field season of 1950 and 1951. Geological mapping of the area was carried out under the direction of J. E. Armstrong and W. L. Brown. The water investigation was supervised by W. L. Brown and much of the water data was collected by him, and by O. Hughes and G. Hughes. Others whose assistance in the field work is hereby acknowledged were: in 1950 - W. M. Draycot, J. G. Fyles, P. 'Odynsky, H. Naismith, J. Allan, and B. Young; in 1951 - Miss F. J. E. Wagner, W. M. Draycot, Rev. R. Sanschagrin, O.M.I., L. F. Brandon, and W. Atamanchuk. The writers would also like to thank all well owners and drillers for their co-operation and willingness to supply information.

Ground-water surveys in this area provide basic information necessary for the future development of domestic, irrigational, industrial, and municipal ground-water supplies. This survey has shown that large ground-water supplies are available in gravel and sand aquifers within 375 feet of the land surface. Although gravel and sand deposits at greater depth undoubtedly contain other ground-water reservoirs the information on them is so meagre that they are not dealt with in this report.

METHODS OF INVESTIGATION

The investigation included the collection of data on 1,342 wells in the area. These records vary greatly in accuracy, as in most cases no drilling data were recorded and the information obtained is based mainly on the memories of well owners and well drillers. The most accurate information was gained from wells being drilled at the time of the survey, as such wells were observed during the course of the work and pertinent data obtained. Later studies in the office showed that on the basis of known geology the information obtained on about 350 wells could be interpreted with accuracy, and only these records are included in this report and plotted on the accompanying map. Information regarding other wells may be obtained from the Geological Survey Office, Vancouver, B.C.

LOCATION AND EXTENT OF AREA

Surrey Municipality covers the south-central part of New Westminster map-area and extends from the Canada-United States boundary (700 feet north of the 49th Parallel) a maximum of 15 miles, to latitude 49°13' N. The eastern boundary follows a meridian a few seconds east of 122°41' W. and the western boundary of the municipality is about 122°53' W. The area of the municipality is approximately 130 square miles.

CLIMATE

The climatic conditions of the Lower Fraser Valley are highly variable and depend upon several factors, the most important of which is the mountain relief north and east of the region (Kelley and Spilsbury, 1939, pp. 9-13)[1]. The annual precipitation varies from 35 inches on the recent delta to 80 inches at the foot of the Pacific Ranges. The characteristic feature of the region is a heavy winter rainfall and a summer dry period. About two-thirds of the annual precipitation occurs during the 6 months from October to March (See Figure at back). The growing season, from April to September, even in wet years has too little precipitation for the maximum development and yield of crops.

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[1] See References, page 8.

Abnormally dry summers, amounting to drought conditions, were experienced in 1951 and 1952. These droughts markedly affected crop production in Surrey Municipality and led to an increased interest in irrigation, and particularly in the use of ground water for this purpose. Although the precipitation for 1951 and 1952 was unusually low the precipitation pattern remained about normal. The annual precipitation pattern, as may be seen from the graph, indicates the paucity of rainfall during the growing season, and, therefore, the necessity of irrigation for maximum crop yields.

The rainfall patterns indicate that annual replenishing of the ground-water reservoirs is readily obtained. The heavy sustained rains from October to March allow a long period for infiltration and keep the soil and sediments above the water-table continually wet. The heavy rains also come in the season when vegetation requires little water, and at a time of the year when humidity is high and evaporation very low. These considerations show that apart from run-off, which is appreciable in some sloping areas, a large proportion of this winter rainfall infiltrates into the soil and becomes a part of the body of ground water beneath the municipality.

AGRICULTURE[1]

The type of agriculture throughout the Lower Fraser Valley is dependent upon local drainage, climate, availability of ground water or surface water for irrigation, soil type, and natural vegetation. The requirements for the Vancouver market, which is the main buyer of the valley's produce, also determines to some extent what is grown.

The Recent delta and lowland areas contain the best farms of the region. These areas, because they lacked heavy timber and bush, were the first to be developed once dyking was completed. Where the peat is less than 6 feet thick

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[1] Kelley, C. C., and Spilsbury, R. H.: Soil Survey of the Lower Fraser Valley; Dept. of Agriculture, Canada, Pub. 650, pp. 14, 15 (1939).

the ground in many places has been cultivated with success, and experiments are continuing, so that the unusable parts of these lowlands, once extensive, are diminishing yearly.

Dairying, mixed farming, and market gardening are the main types of agriculture presently being conducted in the lowland areas.

The uplands with poorer soil and less accessible water do not lend themselves to large scale farming but are made up mainly of small holdings. The higher parts of some of the uplands, with their dry gravel surface mantle, are ideally suited to chicken and turkey raising. This is possibly the most lucrative business of those carried out in the upland areas. Small fruits and vegetables are the principal crops grown on the uplands.

The northern parts of Newton Upland have been extensively subdivided by commuters into a suburban area. Homes surrounded by 5 acres or less are common. This suburban development is presently confined largely to that part of the Newton Upland close to Fraser River. Although little harm is expected from the present suburban development of the uplands, wholesale encroachment of the rich delta farms would materially affect the people living in the Vancouver metropolitan area.

POPULATION

According to the unpublished results of the 1951 census the population of Surrey Municipality is 33,670[1].

TOPOGRAPHY AND DRAINAGE

Surrey Municipality forms a part of the lower Fraser Valley area of southwestern British Columbia, which in turn forms part of the Georgia Depression. The municipality is bounded on the north by Fraser River, which

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[1] Bureau of Statistics, Dept. Trade and Commerce, personal letter.

occupies an apparently post-Glacial valley up to 3 miles wide and 50 feet or more deep, which in turn lies in the lower Fraser Valley lowland area. Fraser River has a length of 790 miles from its source in Yellowhead Pass, and drains an area of 91,700 square miles. It terminates in a delta 19 miles long and 15 miles wide that is still growing.

North and south of the valley of Fraser River and comprising most of the lower Fraser Valley area, including all of Surrey Municipality, are wide, relatively flat-topped uplands separated by wide, flat-bottomed valleys.

Lowlands

All except that part of Surrey Municipality near Fraser River is drained by the Nicomekl and Serpentine Rivers and their tributaries, and Campbell Creek. All three streams obtain much of their water during the dry summer period from ground-water aquifers. Along most of their courses Nicomekl and Serpentine Rivers, and Campbell Creek along the lower half of its course, meander across the floor of flat to very gently undulating valleys from 1 1/2 to 3 1/2 miles wide. These valleys are former embayments of the sea. The main valleys of the Nicomekl and Serpentine vary in elevation from about 5 to 30 feet above sea-level. The valley of lower Campbell Creek is from about 25 to 75 feet above sea-level. Mahood Creek, the principal tributary of Serpentine River, Anderson Creek, a large tributary of Nicomekl River, and the upper part of Campbell Creek all occupy relatively narrow valleys entrenched in the uplands.

Nicomekl and Serpentine Rivers are contained by dykes throughout much of Surrey Municipality as a protection from floods resulting from heavy rainfall, which may occur at any time of the year except the dry summer. Flooding results where a ground-water body is perched so near the surface in the lowlands that the excess rainfall cannot be absorbed, and from rapid run-off in uplands cleared of forest growth for settlement. Nicomekl and Serpentine

Rivers occupy one large valley for the last 5 miles of their courses. This valley is dyked on the seaward side as a protection against tidal flooding. During the winter of 1951-52 these dykes broke when very high tides combined with strong gales.

In Surrey Municipality only small spring-fed creeks drain into Fraser River.

Uplands

The upland surfaces are of two main types: (1) rolling hilly surfaces of glacial till and stony clay, including the Newton, Clayton, and Sunnyside Uplands; and (2) commonly flat, terraced surfaces of glacial outwash, including the Campbell Upland.

Newton Upland. This upland, which is bounded by Fraser River on the north, the Serpentine Valley on the east and south, and the Fraser River Delta on the west, is a rolling hilly surface 200 to 300 feet above sea-level. It is roughly circular in outline,with a diameter of 7 to 8 miles and an area of about 55 square miles. It is bounded in most places by fairly steep slopes, which show, in many places, river or wave-cut terraces. The upland consists of three northwesterly trending, ellipsoidal, high areas separated by two tributary valleys of Serpentine River. The most southerly area has four prominent till knobs that rise to elevations of over 350, 325, 300, and 250 feet above sea-level. The slopes and intervening saddles contain numerous terraces. The middle area is topped by well-formed terraces at 305 and 325 feet above sea-level. Three till knobs rise above the highest terrace to over 350 feet in elevation. The most northerly area contains a large terrace about 200 feet in elevation. The valleys tributary to Serpentine River modify the upland topography with a dendritic drainage pattern. These creeks have numerous spring-fed sources. Each spring is surrounded by a small relatively steep-sided area similar in shape to a box canyon.

Clayton Upland. This upland trends roughly northeast and is bounded on the northwest by Serpentine Valley, on the north by the lowlands bordering Fraser River, and on the southeast and south by Nicomekl Valley. It is a rolling hilly surface 200 to 300 feet above sea-level that is nearly ellipsoidal in outline and about 20 miles square in area. The western extension of the upland surrounding the settlement of Surrey Centre is lower, 125 feet in elevation, and is separated from the main body of upland by a broad saddle 55 feet in elevation. The main upland has one prominent terrace at 250 feet above sea-level. Most of the slopes of Clayton Upland are fairly abrupt and have resulted from wave-cutting, modified by submarine slides and later slope wash.

Sunnyside Upland. This upland, which lies between Nicomekl-Serpentine Valley on the north and Semiamu Bay-Campbell River Valley on the south, is a broad, gently undulating to flat-topped ridge almost ellipsoidal in outline. Three dome-shaped areas occur along the crest of the upland and attain elevations of 325, 350, and 375 feet. The slopes of these areas and the whole upland exhibit marked terraces, there being three prominent terrace levels at elevations of 130, 260, and 310 feet. Less well developed terraces lie between and below these elevations. Many of these can, however, only be observed in small local areas. Large kettle-like depressions occur along the crest of the upland. These are normally not over 3 to 5 acres in extent.

Campbell Upland. This upland is partly in southeastern Surrey Municipality and partly in Langley Municipality. It consists of outwash gravel and sand and has a flat-topped terraced surface 125 to 150 feet above sea-level. It is about 11 square miles in area. The upland, which is an outwash delta, drops off abruptly on the north, west, and south into Nicomekl River and lower

Campbell Creek Valleys. These slopes represent the original depositional slopes. On the east the upland is bordered by a higher upland, the two being separated by a wave-cut slope.

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CHAPTER II

PLEISTOCENE AND RECENT GEOLOGY

GENERAL STATEMENT

The entire municipality of Surrey is underlain by thick deposits of unconsolidated sediments of Pleistocene and Recent ages. The term Pleistocene refers to the period in the earth's geological history immediately preceding the Recent, when great accumulations of ice formed at several centres in Canada. What has been called a Cordilleran Ice-sheet at this time covered all of British Columbia. As the ice advanced, it picked up, transported, and redeposited great quantities of loose rock debris. This material, which is unconsolidated, is called glacial drift, and includes till and stony clay; deposits of stratified drift consisting of gravel, sand, silt, and clay; and scattered boulders. As indicated in the following table of formations of the Surrey area, the ice-sheet advanced and retreated several times and each time left an accumulation of drift. Normal river, stream, and marine sediments were deposited in the intervals separating the advances of the ice-sheet. The term Recent refers, in Fraser River Valley, to that period in the earth's geologic history since the disappearance of the Cordilleran Ice-sheet.

The unconsolidated sediments in Surrey Municipality attain a maximum thickness of at least 1,350 feet; however, as all the aquifers that can at present be usefully developed occur within 375 feet of the surface, only the deposits in this upper part of the section will be discussed.

TABLE OF FORMATIONS

The Pleistocene and Recent geology is summarized in the table of formations inserted in the back of the report. In this table the oldest deposits are shown at the bottom and the youngest at the top. Hence, a hole drilled would penetrate the deposits in the order shown from the top of the table to the bottom except where a deposit has been removed by erosion or locally was not deposited. The deposits included in any one group lie directly above those in the group shown immediately below it, but the deposits included in any one group may be in part contemporaneous.

GENERAL DESCRIPTION AND HISTORY

Surrey Municipality was covered by three major advances of the Cordilleran Ice-sheet. Each advance produced a glacial till, which is a compact sandy clay containing stones commonly called hardpan. The three tills, from the oldest to the youngest, have been named Seymour, Semiamu, and Surrey.

Stony clay, till-like in appearance and of mixed glacial and marine origin, is associated with the Seymour and Surrey tills, but only that in the latter occurs in Surrey Municipality. Silt, sand, and gravel deposited by streams resulting from the melting of an ice-sheet are called outwash deposits and are normally deposited during the advance and retreat of an ice-sheet. The Abbotsford outwash may represent a late minor advance of the Surrey ice-sheet as it is separated everywhere from Surrey till by Newton stony clay. Gravel and sand included in Semiamu sediments is the only known outwash associated with the Semiamu ice-sheet, and these sediments also include clay, silt, and sand of probable glacial lake origin.

During and following the advance of the Seymour and Surrey ice-sheets, which were upwards of 7,500 feet thick, all of Surrey Municipality was depressed below sea-level. (Information is insufficient to determine whether the Semiamu ice-sheet also brought about depression of the Surrey land surface below sea-level.) When the land was depressed and as it rose again after retreat of the ice-sheets, sediments were laid down in the sea as bottom, littoral, estuarine, and deltaic deposits, and along the streams and rivers as flood-plain and channel deposits. During and following the retreat of the Seymour ice-sheet, Point Grey beds, Nicomekl silt, and probably Sapperton sediments and Colebrook gravel were deposited, and during and following the retreat of the Surrey ice-sheet Newton stony clay, Abbotsford gravel, Cloverdale sediments, Sunnyside sand, Bose gravel, and Alouette gravel were deposited.

When the uplands of Surrey eventually rose above the sea they were subjected to erosion, the sediments so produced being deposited in the low-lands. These erosion intervals are noted in the table of formations.

The Salish deposits, which are still in the process of formation, consist of silt, clay, and sand deposited by Fraser River and smaller streams, and the peat bogs.

A study of the accompanying geological map will show that the Capilano deposits, except for the Bose gravel and Sunnyside sand, and the Salish deposits, are confined to the lowlands. The uplands in most places are mantled by Newton stony clay and Surrey till. In many places veneers of Bose gravel and Sunnyside sand are found above these.

CHAPTER III

GROUND-WATER GEOLOGY

GENERAL CONSIDERATIONS

Ground water, or underground water, is the water that supplies springs and wells. The finding of potable ground-water supplies has long been of profound importance to man. In arid and semi-arid regions the presence and development of ground water has been a major factor in the growth or absence of civilizations. Only within the relatively recent past have the people living in humid regions come to realize what an important natural resource exists beneath the earth's surface in the form of ground water, especially in those areas of great concentration of population where surface streams are insufficient and contaminated. In other areas, such as lower Fraser Valley, where the annual rainfall, although copious, is scanty in the growing season, ground water has become an important source of water for irrigation and domestic purposes. Even where large surface supplies are available it is commonly more economical, when good engineering practices are used, to allow the natural conduits in the rocks and sediments beneath the earth's surface to carry water to the user, than to construct large, long pipelines or aqueducts.

Source

Most ground water is derived from precipitation in the form of rain or snow. Part of the water that falls in this manner is carried away by surface run-off, part of it percolates downward into the underlying unconsolidated sediments until it reaches the water-table where it joins the body of ground water in the zone of saturation, and part of it evaporates or is absorbed and transpired by vegetation and is thus returned directly to the atmosphere.

A layer of water 1 inch deep over an area of 1 square mile amounts to approximately 14,520,000 imperial gallons. As the average annual precipitation in the form of rain and snow that falls on Surrey Municipality is 40 inches, it will be seen that each year some 580,800,000 imperial gallons of water falls on each square mile. The accurate determination of the amount of rainfall entering the ground-water body each year beneath Surrey Municipality was considered beyond the practical scope of this survey, but, because the answer to this problem is of paramount importance, the writers have made the following rough estimate of the amount. The figure is believed to be about 4,500,000,000 imperial gallons a year or about one-seventeenth of the total amount of water that falls as rain or snow upon the municipality.

Occurrence

Ground water occurs in the open spaces and pores of both consolidated rocks and overburden near the surface of the earth. These openings range in size from huge caverns in limestones to minute, microscopic, and even submicroscopic pores in fine-grained material. They form the receptacles and conduits for ground water, and their size, shape, and relation to one another largely control both the quantity of ground water that occurs in any area and the rate of its movement through the ground to any pumping well or spring. Fine-grained rocks such as clays and shales are, therefore, poor sources of ground water and coarser grained materials such as sand and gravel are more satisfactory. By far the most productive water-bearing beds in Surrey Municipality are deposits of sand and gravel interbedded with or lying below more impervious clay or till.

Water-table and Movement of Ground Water

The water-table is defined as the upper surface of the zone saturated by free ground water. The pores or spaces of the rock or sediment above the water-table are only partly filled with water, most of which is slowly travelling downwards to the water-table. Below the water-table all the open spaces of the rock or sediment are filled with water, in what is called the zone of saturation. Free ground water is the water in this zone down to the first impervious barrier. Confined ground water is the water separated from the free ground water by an impervious barrier. In places confined ground water exerts a pressure against this barrier, and water will rise in a well that pierces the barrier. If the water rises in the well and overflows at ground surface, the well is called a flowing artesian, but if the water rises only part way to the surface the well is known as a non-flowing artesian. The surface to which artesian water will rise is known as a pressure or piezometric surface.

The water-table is a constantly changing surface that fluctuates up and down in response to the amounts of water that are either added to or subtracted from the ground-water reservoirs. The water-table beneath Surrey Municipality is raised by rainfall and by subsurface drainage from adjoining areas to the east. Any lowering of the water-table is the result of water removed by wells and springs, and the movement of ground water passing beneath the surface into adjacent areas. Direct evaporation from the ground and transpiration through plants is less important in the decline of the water-table.

In areas where the depletion of the ground water by the above factors is only a fraction of that contained in the ground-water reservoir the water-table fluctuation will be negligible. Also if a water-bearing bed or aquifer is full, then no more water can be added and the water-table will not rise in response to heavy rainfall. The writer believes many of the ground-water reservoirs of Surrey Municipality are full and are being depleted by wells and springs at so small a rate that fluctuations of the water-table are, for practical purposes, absent. Such reservoirs would stand considerable pumping before the water-table is lowered and rainfall can replenish it. Other water-tables, especially those near the surface of the uplands, show marked fluctuations because the water-table is constantly moving downwards during the summer months and the permeability of the aquifers is low. Dug wells that do not extend below the lowest level reached by the water-table in these sediments go dry in summer.

Recharge

The addition of water to the underground reservoir is called recharge. The water beneath Surrey Municipality is derived from water that falls chiefly as rain or snow either within the municipality or on the adjoining areas of the lower Fraser Valley.

As already stated the average annual precipitation of Surrey Municipality is 40 inches but probably only about one-seventeenth of this enters the ground-water body. The amount of water that recharges the ground-water body depends upon several factors, the most important of which are the type of sediments or soil at ground surface, the depth to the water-table, and the topography of the surface. For example, the large gravel terrace deposited as a delta by a former, and larger, Campbell Creek, near the southeastern boundary of the municipality, is an area of high recharge because the sediment composing this terrace is coarse sand and gravel, the water-table is within 20 feet of the surface, and the surface is flat.

Subsurface inflow is the movement of ground water beneath the surface down the slope of the water-table from adjacent areas to the area being studied. Considerable inflow takes place in the region of upper Campbell Creek from parts of the terrace in Langley Municipality, and extends down the wide valley of this creek. Inflow is also effective in the upland east of Cloverdale from Langley Municipality. The springs described below also help to recharge the water reservoirs under the lowlands. Some recharge is effected from flowing artesian wells permitted to flow freely.

Discharge

Natural discharge from the ground-water reservoirs takes place from springs and subsurface outflow, with a minor amount subtracted by evaporation and transpiration. In Surrey Municipality most of the discharge takes place as springs at the headwaters of Campbell Creek, Serpentine and Nicomekl Rivers, and their tributaries. Most of these springs are at the base of the uplands. Some submarine discharge may also take place.

The exact amount of ground water used at the present time in Surrey Municipality is not known but is estimated to be about 615,000,000 gallons a year, which is about one-seventh of the estimated potential recharge of 4,500,000,000 gallons a year.

GROUND-WATER RESERVOIRS

General Statement

The complex Pleistocene geology of Surrey Municipality has resulted in the formation of three main types of ground-water reservoirs, namely, perched free ground water, perched confined ground water, and floating groundwater, the last probably also perched. The term confined is used to refer to ground water confined vertically but not necessarily horizontally.

Perched ground water occurs in a saturated zone separated from the main body of ground water by impervious sediment. Perched water bodies in Surrey generally rest on clay, stony clay, or till. They may be confined or free.

Free ground water is the water in interconnected interstices in the zone of saturation down to the first impervious strata. It moves under the control of the water-table slopes.

Floating ground water is defined as a body of fresh ground water floating on salt ground water. This happens because fresh water has a specific gravity of 1.000 and sea water a specific gravity of 1.025. Floating water bodies are found near the sea.

The classes of wells referred to in this report are as follows: flowing artesian wells, non-flowing artesian wells, and non-artesian wells. Flowing artesian wells are those in which the water is under sufficient pressure to flow above the surface of the ground at the well. Non-flowing artesian wells are those in which water is under hydrostatic pressure sufficient to raise it above the level at which it was encountered in the well, but not above the level of the ground. Non-artesian wells are those in which the water does not rise above the surface of the water body. Both artesian and non-flowing artesian wells are found in Surrey when perched confined water reservoirs are pierced. Non-artesian wells are found mainly in the perched free-water reservoirs but there are also some in vertically confined water bodies that are open horizontally.

Throughout much of Surrey Municipality the writers have noted that in most places the piezometric surface, or the surface to which ground water will rise in an artesian well, of the several confined perched ground-water bodies occurs at practically the same elevation in any one place.

It has also been noted that the surface of the extensive free ground-water bodies and the non-artesian confined ground-water bodies underlying some of the uplands corresponds approximately to the piezometric surface of the confined artesian ground-water bodies in the same area. The combined surface of the ground water in the artesian and non-artesian wells shows a marked parallelism with the ground surface. These features suggest that the water-tables are interconnected. The record of adjoining wells over several years and the record of new wells would seem to confirm this statement.

Perched, Free Ground-water Reservoirs

Large areas of Surrey are underlain by perched, free ground water. The Newton stony clay, which mantles most of Newton, Clayton, and Sunnyside Uplands, although nearly impervious, is capable of passing small quantities of water everywhere, especially where it contains small lenses of coarser material. It thus forms a perched, free ground-water reservoir of very limited storage capacity and shallow wells dug in it will yield a small supply of domestic water. Yields may be up to several hundred gallons a day but generally are under 100 gallons. These wells probably act mainly as natural cisterns, that is, they fill up during the rainy season, and if placed to take advantage of local slopes, they catch natural drainage during the dry periods. As the water-table lowers during dry periods they tend to go dry, especially if they are too shallow or have too limited a storage capacity. Perched, free ground water is also present in the lowland areas where Sunnyside sand overlies Cloverdale clay. These areas are suitable for dug wells but the water-table fluctuations are usually large.

The Campbell Upland, which is underlain by Abbotsford outwash sand and gravel, contains a large, perched, free ground-water reservoir that may be reached by 25-foot wells. Wells in this area yield copious amounts of water and have a seasonal fluctuation of less than 3 feet. The low water period is in the early autumn.

Perched, Confined Ground-water Reservoirs

Perched, confined ground-water bodies, including non-artesian and artesian reservoirs, are found within 375 feet of ground surface throughout 95 per cent of Surrey Municipality. As many as three water bodies have been pierced by a single 350-foot well. The following deposits serve as aquifers for ground water in the area; Colebrook, Sapperton, Nicomekl, Semiamu, Point Grey, Lynn, and pre-Seymour gravel and sand.

The most easily reached and widely developed aquifer is in the Colebrook outwash gravel, which underlies Surrey till. Its position cannot always be determined before development because the gravels appear to occupy channels in the sand. However, it is normally present near the crests of the main upland slopes, and near the toes of some of these slopes, and these areas are, consequently, most favourable for relatively shallow wells from 30 to 100 feet deep. Other gravel deposits form equally good aquifers but are generally deeper or more limited in extent.

Floating Ground-water Reservoirs

These aquifers are unimportant sources of potable water in Surrey Municipality. They exist in the Mud Bay region where brackish water is available within 25 feet of the surface in Richmond Delta sand.

CHAPTER IV

PRINCIPLES OF WELL DEVELOPMENT

GENERAL STATEMENT

The main purpose of this section is to draw the attention of engineers, drillers, and prospective well owners in Surrey Municipality to certain fundamental principles of ground-water recovery and well use, that they may know the problems that exist and the safeguards or corrective measures that are being employed elsewhere. Those interested in the subject of well construction may obtain much valuable information from drillers magazines and from some of the books listed in the References on page 8 of this report.

Basically, wells serve only one purpose and that is to tap the ground-water reservoir and make economically available the required amount of water. Economic factors and the ability of the driller and his equipment govern how efficiently and how long a well will produce. A well should be more than a hole in the ground or a hole lined with some type of casing. It must be developed properly before it can be of lasting and effective use. For example, wells that pump sand will eventually fail because a cavity will form at the bottom of the casing, which will collapse in time and greatly decrease or even stop the flow.

Two important and related factors to be constantly borne in mind are the influence of the well, due to draw-down, on the surrounding area, and its capacity to produce. The former is the effect of the 'cone of depression' and the latter is the 'specific capacity' of the well.

Cone of Depression. When a well is pumped the water level may fall around the well due to the dewatering of the water-bearing or storage material. The shape of the water surface around the well is, then, that of an inverted cone, which is known as the 'cone of depression'. The size and shape of this cone of depression is controlled by several factors, such as the rate of pumping, the permeability or water-yielding capacity of the water-bearing material, and the slope of the water-table in the vicinity of the well. For example, if the pumping rate is high and the water-bearing sediment is coarse, then the cone of depression will affect a large area of the water-table, but the height of the inverted cone will be relatively small. Under these conditions many neighbouring wells may be affected. When the pumping is stopped the dewatered area normally fills up again. On occasions a small lowering of the water-table may be more less permanent.

Specific Capacity. The 'specific capacity' of a well is its rate of yield per unit of draw-down, usually stated as the number of gallons per minute, per foot of draw-down. The specific capacity of a well should be known, especially when large flows are demanded, because it tells the well owner how much water he can expect from the well and the depth from which he may have to pump. When testing for specific capacity it is important to continue pumping until the water level remains constant. Under some conditions it may take several days for this to happen and the equilibrium of the cone of depression to be established.

TYPES OF WELLS

General Classification

There are four main types of wells: dug, bored, driven, and drilled. Each type has its special use and function under certain conditions. In some areas of the municipality one type may prove more valuable than another. The factors that determine the type of well to use are: depth to water, characteristics of the sediments from ground surface to the water, characteristics of the water-bearing sediments, the static level of the ground water, the amount of water required, and the purchasing power of the prospective owner. Drilled wells (which are cased in Surrey Municipality as the wells are in unconsolidated materials) may also be subdivided into open-end, screened, and gravel-packed.

Dug wells are of limited usefulness in Surrey Municipality because the depth to abundant water supply normally exceeds 30 feet and because the ground water beneath large areas of the municipality is under hydrostatic pressure, beneath a confining impervious bed. Where small quantities of water are required for domestic use, however, dug wells may give sufficient water at a minimum cost. The areas where dug wells may be expected to give good results are the terrace areas of the municipality. These areas are mainly covered by at least 10 feet of gravel, sand, and Newton stony clay. This last material, which is a marine deposit and easily dug, yields small quantities of water to wells. When locating a dug well attention should be paid to the irregularities of the ground surface. The well should be dug in the largest and flattest area available because low knobs on the terrace areas are normally composed of glacial till or hardpan from which little water can be expected other than stored water. On the lower slopes of the upland near the spring line, dug wells may pass through glacial till within 15 feet of the surface and get good reliable supplies of ground water from the underlying sand or gravel. These wells do not go dry because they tap one of the main ground-water reservoirs of the uplands that feed the springs. Another area where dug wells give good results is the large gravel terrace in the south-eastern section of the municipality known in this section as the Campbell Upland. Here the water-table is within 20 feet of the surface and the water is in outwash sand and gravel that covers the terrace.

In many parts of Surrey the presence of quicksand may make it difficult to dig a well the necessary few feet below the water level. The dug well must have several feet of water in it before it can be pumped at a rate greater than the domestic requirements of 200 gallons a day. Dug wells that reach running sand or quicksand may yield enough water if sand points are driven into the bottom of the well.

Bored wells, sunk by means of a hand auger or power auger, are not widely used and so will not be discussed in this paper.

Driven wells, which are constructed by driving a casing tipped with a drive point or sand point, are used in some areas of Surrey Municipality. These wells can produce adequate quantities of water for domestic and stock use. The advantage of this type of well over the dug well is that such a well can be driven some distance below the top of the water-table and the temporary cone of depression so formed may be sufficient to allow the required amount of water to be pumped.

In the lower Campbell Creek Valley wells driven in clay and soft stony clay will produce water from a depth up to 55 feet. The main difficulty in this area is caused by stones in the lower clays, which stop the driving of the well. Those areas where there is ground water in sand appear well suited for driven wells.

Drilled wells are widely used throughout the municipality. Cable tool rigs appear to be best suited for drilling in the lower Fraser Valley. Those who have used rotary rigs have experienced great difficulties where heavy outwash gravels were encountered, and there are many unsatisfactory wells that might have yielded several times their present production over long periods of time had they been properly constructed. As mentioned earlier, cased drilled wells may be classified according to the opening provided for water to enter.

<u>Open End Wells.</u> These wells allow water to enter through the open end of the casing. No screen or other device is used to keep sand from entering the well. The open end, cased, drilled well is widely used throughout the municipality but is unsatisfactory in many places where the water-bearing sediment is sand. Under such conditions the only alternative to doing a proper development job is to keep the production of the well very low so that sand will not move up the well with the water.

<u>Screened Wells.</u> These are wells with a screen at the lower end to prevent the passage of fine sand into the well. A screen should be designed to allow the maximum flow of water without permitting the entrance of fine sand during production. The screen must be designed so that it will withstand development and surging without clogging.

In water-bearing materials that contain sand and fine gravel mixed with silt, a screened well may be developed by removing the fine sediment and concentrating the coarser material around the screen. This is done by surging the water in the well. After the well has been surged for a suitable length of time the fines are bailed from the inside of the screen. It is important to remove all the fines inside the screen because a screen normally operates most effectively near the bottom. The process should be repeated until the well, when pumped, will not produce sand, and may take a few hours or several weeks depending upon the size of the well and the composition of the water-bearing sediment. In wells of small yields the over-pumping method of development may be used. The well is pumped at an excessive rate until it ceases to pump sand. This method is not entirely satisfactory but it will give sufficient development for many low yield wells. Another method of development is known as back-washing, where the pump is operated at its maximum capacity and periodically stopped and the foot check value released. The water then rushes back into the well and agitates the sediment around the screen. The importance of developing sand wells properly is becoming better appreciated by those using ground water for municipal, industrial, irrigational, and farm use, and drillers would be wise to study the art and refine their techniques because proper development is an absolute necessity for large wells.

Gravel-packed Wells. Under certain conditions, especially where no particles coarser than medium sand are involved, a well may be developed by artificial gravel packing around the outside of the screen. The gravel is placed outside the final casing and screen, that is, between the screen and the water-bearing sediment. This may be effected through pilot holes or through a hole drilled larger than the diameter of the final well. Gravel-packed wells are satisfactory under certain conditions, especially when the water-bearing sediment is medium to fine sand.

CHAPTER V

GROUND-WATER GEOLOGY OF SURREY MUNICIPALITY

The topographic units described below are merely convenient subdivisions for the discussion of the ground-water geology of Surrey Municipality. The aquifers or ground-water reservoirs discussed in this section are those within 375 feet of ground surface. These bodies will yield a constant supply of potable water to properly developed, drilled, driven, or dug wells.

NEWTON UPLAND

Water for the western and northwestern parts of Newton Upland is presently supplied by a part of the Surrey Municipal Water Works, which obtains it from the Greater Vancouver Water Board. This water comes from Coquitlam Lake and reaches the area via a main at South Westminster. The existence of this supply system made it almost impossible to obtain useful information about the ground-water geology of that part of Newton Upland west of King George Highway. The municipality installed the distributing system to handle surface water as there was no information available on the possibility of an adequate ground-water supply. However, the wells in secs. 17 and 20, tp. 2, show that confined artesian ground water is present. The well recorded as 2-17-1 struck water in Colebrook gravel within 50 feet of ground surface and yielded a supply in excess of 2,000 gallons an hour. Extrapolation of the results obtained from other parts of Newton Upland and from other uplands suggests that ground water is present in this area in large quantities.

The sands and gravels of the Colebrook outwash and the sands of Sapperton sediments, Nicomekl silt, and Point Grey beds are the main developed aquifers beneath Newton Upland.

Water Reservoirs

At least one free and three confined ground-water reservoirs, vertically below one another, are present in much of Newton Upland. They are believed to be interconnected as the height to which the water rises in the wells seems to be about the same, regardless of which body is supplying the water. Possibly the explanation may be that all the porous sediments below the upper water body are completely saturated.

The undulations in the surface formed by the height at which the water stands in the wells in that part of the area where information is available closely parallel the topographic surface. In those parts where the elevation of the ground is over 175 feet this surface has a more subdued topography than that of the ground above it, and its slope varies between 25 and 75 feet a mile. In the northeastern parts of Newton Upland the crest of this surface is southwest of the topographic ridge. Below ground elevations of 150 feet the surface of the well water drops steeply, at slopes between 300 and 500 feet a mile, except in Mahood Creek Valley where more gentle slopes of 100 to 200 feet a mile are present. In places near the 100-foot topographic contour a ground-water cascade is present. There the surface of the well water drops 75 feet in about one-twentieth of a mile. A spring line also exists near this contour. These features indicate the presence of an impervious bed or beds, probably the Semiamu till, at this elevation. However, the lack of good exposures and the similarity between Semiamu and Surrey tills in small outcrops makes it impossible to be sure. The springs issue from areas where Surrey till is breached and an alternative hypothesis is that they are the result of the intersection of the surface ground-water body and the topographic surface.

The water reservoirs of Newton Upland apparently suffer only slight seasonal fluctuations. Several well owners report that their wells contain more water during the summer drought than in the winter rainy season. This may be caused by a lag in the movement of ground water from the recharge areas, which are covered by Newton stony clay, to the water reservoirs. Climatic conditions demand maximum recharge during the late autumn, winter, and early spring with little or no recharge during the late spring, summer, and early autumn. The existence of high water in wells during the summer and low water during the late autumn and early winter shows that the water reservoirs are about 4 months behind the seasonal variations in precipitation.

Ground-water Recharge and Discharge

The main recharge areas of Newton Upland are those areas above 260 feet in elevation, particularly the marine terraces close to 260 and 305 feet, which are covered by Newton stony clay. Small upland areas above 250 feet are present from which the Semiamu and Surrey tills have been eroded and Colebrook outwash or lower deposits are at or near the surface. It is difficult in the field to outline these areas in detail but observations show that such areas do exist. The Newton stony clay deposits, although superficially similar to till, transmit limited quantities of water. This water moves along planes of sub-stratification and in the lenses of silt and sand.

The recharge area north of Mahood Creek is estimated to be 4 square miles in extent. The total recharge area of the upland is estimated to be 10 square miles.

The following method is used for estimating the amount of recharge in the clay-mantled upland areas. One inch of rain on 1 square mile contains approximately 14,520,000 imperial gallons. The average annual precipitation of Surrey Municipality is about 40 inches. Conservatism demands that the estimate of run-off, evapotranspiration, and percolation of ground water into adjoining areas be assumed to be 90 per cent. Thus, 10 per cent, or 4 inches of rainfall, is available to recharge the aquifers, and 58,080,000 imperial gallons of water can safely be assumed to be available per square mile of recharge area annually. The recharge from Newton Upland can, therefore, be estimated to be about 580,000,000 imperial gallons a year. Inflow from adjacent areas is believed to be negligible to the aquifers within 375 feet of ground surface of Newton Upland.

Serpentine River and its tributaries are effluent during the periods of low rainfall, but data are not sufficient to give an estimate of the amount of ground water lost to these streams.

Recovery of Ground Water

Drilled and dug wells recover the ground water of the upland. The drilled wells are non-flowing artesian wells and obtain their water from perched, confined ground-water bodies. The dug wells are mainly non-artesian wells obtaining their water from perched, free ground-water bodies and to a lesser extent perched, confined ground-water bodies. A few are, however, non-flowing artesian. No well in the municipality has as yet been properly developed. Most dug wells do not penetrate more than a few feet into the aquifers so that at best only a small cone of depression can be created around them. The drilled wells consist of either wholly or partly cased holes that are neither gravel packed nor screened. The drillers apparently hoped that a natural arch would form at the bottom of the hole, but even if such an arch were to form it would be unstable. Wells in

Colebrook gravels, however, become gravel packed by normal pumping. The absence of properly developed wells makes it impossible to obtain an estimate of maximum yields to be expected from this deposit.

CLAYTON UPLAND

The ground-water geology of Clayton Upland is similar to that of Newton Upland.

The Colebrook outwash, Nicomekl silt, Sapperton sediments, and Point Grey beds form the main aquifers of the Clayton Upland, the Colebrook being present along the slopes.

Water Reservoirs

In the eastern part of this upland the piezometric surface reflects the topography. This surface apparently has gentle slopes above an elevation of 250 feet, but near the 200-foot topographic contour the slope increases to about 400 feet a mile. Below 100 feet, the slope flattens to between 35 and 75 feet a mile. The steep part of this surface may be likened to a ground-water cascade similar to that in Newton Upland. The projected surface of the static levels of the wells (the piezometric surface) slopes towards Nicomekl Valley more gently than towards Serpentine Valley. A narrow ground-water "ridge" extends westward from the main part of Clayton Upland across the topographic saddle north of Cloverdale village to the small upland area west of the village.

Ground-water Recharge and Discharge

A recharge area is present on the subdued terrace above an elevation of 260 feet. This infiltration area is believed to be 3 miles square in Surrey Municipality with Newton stony clay mantling most of it. The total infiltration area for the whole upland is probably 5 square miles. This would allow the infiltration of 290,400,000 imperial gallons a year into the entire Clayton Upland and 174,240,000 imperial gallons a year into that part of it in Surrey Municipality.

The natural discharge is from springs, some of which feed small streams tributary to Nicomekl and Serpentine Rivers.

Recovery of Ground Water

Ground water is recovered by numerous privately drilled and dug wells on the upland slopes. As will be seen from the tables, both non-flowing artesian and non-artesian wells occur and obtain their water from perched confined, and perched free ground-water reservoirs. These wells are not properly developed so that yields are low in most wells.

SUNNYSIDE UPLAND

Hydrologic data for Sunnyside Upland is insufficient to allow more than a general discussion of the ground-water conditions.

On this upland the main aquifer is also the Colebrook outwash, but pre-Surrey sands produce considerable quantities of water even to the poorly developed wells of the upland.

Water Reservoirs

The projected surface of the static levels in the wells slopes abruptly downward on all sides from the centre of the upland. This is because the upland itself slopes steeply on all sides, particularly to the south and west where waves have cut cliffs up to 125 feet high. A spring line is present along these cliffs above Semiamu till and varved clays, at an elevation of about 90 feet. The slopes range from 350 to 5,000 feet a mile along the southern face of the upland.

Ground-water Recharge and Discharge

The main recharge area for Sunnyside Upland is about 4 square miles in extent and is covered by Newton stony clay. It ranges in elevation from 260 to 325 feet. Recharge from the eastern knob of the upland is believed to be negligible. Inflow from the Campbell Upland is believed to recharge the water reservoir below 75 feet in the eastern parts of the upland. If the assumption made for Newton Upland is correct the annual recharge of the water bodies, exclusive of inflow, is estimated to be about 230,000,000 imperial gallons.

The natural discharge is from springs along the upland slopes close to 90 feet above sea-level. More springs issued from the southern than from northern slopes.

Recovery of Ground Water

Dug and drilled non-flowing artesian and non-artesian wells recover the ground water from the perched confined and free ground-water reservoirs of the upland. None of these wells are fully developed. Four water concerns, using the ground water of Sunnyside Upland, presently supply water to the upland's inhabitants. These four concerns are the White Rock Water Works Company, Limited, the Crescent Beach Water Works, Limited, the Kensington Prairie Water Users Community, and Surrey Municipality Water Works.

The White Rock Water Works Company is situated in the village of White Rock at the base of the southern slope of Sunnyside Upland in sec. 10, tp. 2. It supplies the village and the adjoining areas to the north and west. In 1949 it supplied 1,750 domestic and 76 commercial users. The water is obtained from three drilled wells, Nos. 2-10-1, 2-10-2, and 2-10-3. These wells, two of which are 8 inches in diameter and one of which is 6 inches in diameter, are flowing artesians with a static water level a few feet above ground surface. They are not developed beyond having slotted casings and having been surge pumped. Sand and gravel aquifers are present at approximate elevations of 50, 100, and 150 feet below sea-level. These aquifers are probably outwash sediments related to the advance of Semiamu or Seymour glaciers. The natural flow of each well is about 7,500 imperial gallons an hour, but with pumping to a near static level of 11 feet, the three wells together can produce over 900,000 imperial gallons a day. The maximum amount supplied up to the time of the writer's visit was 650,000 imperial gallons a day, at which time many water pipes were broken because of a deep frost. The manager, Mr. W. E. Johnson, believes that the wells could supply 1,000,000 imperial gallons a day. Although the wells are less than 1/8 mile from tide-water and are obtaining water from up to 150 feet below sea-level, no salt water has invaded the wells. An analysis supplied by Mr. Johnson reported only 76 p.p.m. chloride ion.

The Crescent Beach Water Works, Limited, which is situated on the northeast point of Sunnyside Upland in sec. 19, tp. 2, supplied 386 domestic, 3 commercial, and 1 industrial user in 1949. It derives its water from one drilled well situated 10 feet above sea-level at the toe of the upland slope. The well is 8 inches in diameter and is reportedly 28 feet deep. This well produces an estimated maximum of 40,000 imperial gallons a day.

The Kensington Prairie Water Users Community was established by the residents near a spring area in NE. 1/4 sec. 24, tp. 2. Twenty families are supplied by this system. The springs feed a small reservoir and issue from sands underlying Surrey till at an elevation of 48 feet. Numerous other springs are present in this area between Blake and Coast

Meridian roads. Surrey till outcrops on three sides of the springs so that surface contamination from run-off water could be readily prevented by digging ditches in the till to the west, south, and east of the spring. These springs could possibly produce 500,000 imperial gallons a day. However, because many of the springs issue from beneath forest litter, clearing would be necessary before a reliable estimate of flow could be made.

Surrey Municipal Water Works are presently constructing a water system to supply the eastern highland area of Sunnyside Upland. The water for this system will come from three or more drilled wells on the south slope of the upland in sec. 7, tp. 7. These wells are recorded as 7-7-2. They are undeveloped, 10-inch cased wells, and obtain water from an elevation of 110 feet below sea-level from medium to fine grey sand that probably belongs to the Point Grey beds. The quantity of ground water flowing from these wells is approximately 500 imperial gallons an hour. The three wells produce about 36,000 gallons a day by natural flow.

The total amount of water that can be produced by these four water works is approximately 575,000,000 imperial gallons a year. The estimated recharge at the surface of the upland was 230,000,000 gallons a year. Thus, either the estimated rate of infiltration is too low or there is considerable inflow to the water reservoirs near the base of the upland slopes, where these water works obtain their supply. The writer believes the latter to be the case, the inflow coming from Campbell Upland.

CAMPBELL UPLAND

Campbell Upland is underlain by Abbotsford outwash sand and gravels. It has an area of 10 square miles of which only 3 square miles are in Surrey Municipality.

Water Reservoirs

A perched, free ground-water reservoir conforms closely to the topography of the terraced upland. The slope of the table away from the terrace front is less than 25 feet a mile, whereas near the front and adjacent to the valley of Anderson Creek the slope steepens to 200 feet a mile. East of lower Campbell Creek Valley the slope is 50 feet a mile.

Observations made in a gravel pit on Hunter Road in SE. 1/4 sec. 22, tp. 7, during the 1951 drought, showed that the water-table dropped 3 feet during July and August. The water remained at the lowered level until November in spite of 2 inches of rain during September and October. This was not enough to soak thoroughly the 15 feet of gravel overlying the water-table.

The Abbotsford outwash forms the main aquifer of the area, but towards the northwest slope of the terrace water also comes from older deposits.

Ground-water Recharge and Discharge

Campbell Upland is ideally suited for an infiltration area. The flat topography of the terraced upland and the coarseness of the outwash suggest that at least 60 per cent of the precipitation that falls upon this area will infiltrate to the water-table. If this is correct, about 3,500,000,000 imperial gallons will enter the aquifers each year from the whole area of the upland. Inflow from the uplands to the east is also large.

Anderson Creek and the lower part of Campbell Creek are effluent streams during the summer season. Dug, non-artesian wells, up to 40 feet deep, are presently being used to recover the ground water.

CAMPBELL CREEK LOWLAND

Campbell Creek Lowland receives its perched, confined artesian ground water from the inflow from Campbell Creek Terrace and a minor amount from Sunnyside Upland.

Water Reservoirs

The artesian water bodies beneath the lowland have a relatively flat piezometric surface that slopes westward, down the valley, at about 12.5 feet a mile between hydrostatic heads of 75 and 50 feet. To the east, near Campbell Upland, the slope is 50 feet a mile and near Sunnyside Upland the slope averages 150 feet a mile. Except in very dry summers a shallow, perched, free ground-water reservoir occurs in the Sunnyside sands occupying the Campbell River Lowland.

Pre-Surrey sands form the aquifers beneath this lowland.

Ground-water Recharge and Discharge

No recharge area exists beneath this lowland and most of the ground water comes from Campbell Upland, with a minor amount from Sunnyside Upland. Campbell Creek flows over relatively impervious Cloverdale clay and has no apparent effect upon the water-tables.

The water bodies beneath Campbell Creek Lowland have no apparent natural discharge. Flowing artesian wells that are undeveloped and allowed to flow constantly provide an artificial discharge, and an estimated 13,000,000 imperial gallons a year from these wells is wasted.

The area is developed almost entirely by drilled wells obtaining flowing artesian water from perched, confined ground-water reservoirs.

NICOMEKL-SERPENTINE LOWLANDS

This lowland area, which separates Newton, Clayton, Sunnyside, and Campbell Uplands is an area of flowing-artesian wells.

Water Reservoirs

Perched, flowing artesian ground-water reservoirs are the most important aquifers in this lowland. The combined piezometric surface on these artesian bodies is relatively flat and trends down the valleys of Serpentine and Nicomekl Rivers with a gradient of about 4 feet a mile. The centre line of the piezometric surface is midway between Newton and Sunnyside Uplands in the Mud Bay region, but is closer to Clayton Upland in both the upper Nicomekl and Serpentine Valleys. A divide is present on the piezometric surface near where the Trans-Canada Highway crosses the upper Serpentine Valley. Northeast of this divide is a depression in which the piezometric surface drops about 20 feet. Except in very dry summers a shallow, perched, free ground-water body occurs in the Sunnyside sands occupying the Nicomekl-Serpentine Lowland.

The main aquifers are pre-Surrey, probably Nicomekl, Sapperton, and Point Grey sands. Near Cloverdale village some wells penetrate Colebrook gravels.

Ground-water Recharge and Discharge

No surface recharge areas are present in the Nicomekl-Serpentine Lowland. Recharge for the aquifers is by means of inflow from the adjoining uplands. The Campbell Creek Upland furnishes most of the ground water of these lowlands. In the upper Serpentine Valley the shape of the piezometric surface suggests that more inflow comes from Newton Upland than from Clayton Upland.

No obvious natural discharge takes place in this lowland area. Nicomekl and Serpentine Rivers, in the lowlands, are perched and are, therefore, neither effluent nor influent.

Recovery of Ground Water

Ground water in this Lowland is recovered from a number of flowing artesian wells. The wells are undeveloped and flow continuously the year round. The resulting waste of ground water is estimated at about 13,000,000 imperial gallons a year.

CONCLUSIONS AND RECOMMENDATIONS

The recharge areas for the ground-water reservoirs of Surrey Municipality are situated on Newton, Clayton, and Sunnyside Uplands above an elevation of 260 feet, and on Campbell Upland. A conservative estimate suggests that 10 per cent of the precipitation infiltrates to the ground-water reservoirs from the first three uplands and that 60 per cent infiltrates from Campbell Upland. That is, about 4,500,000,000 imperial gallons a year recharge the water reservoirs artesian wells does not re-enter the confined ground-water body but drains directly to the sea. The present consumption of ground water is probably about 600,000,000 gallons a year, based on the estimate that every inhabitant of the municipality uses 50 gallons a day. The remaining 3,900,000,000 imperial gallons a year of the estimated recharge would supply enough water to irrigate 25 square miles of land with 10 acre-inches during the summer drought period.

The present survey is preliminary and the figures given must be considered as estimates. Only those water reservoirs within 375 feet of ground surface have been investigated and, as the unconsolidated deposits have a total thickness of about 1,350 feet, other aquifers may exist at greater depths.

Carefully engineered development would supply Surrey Municipality at reasonable cost with enough ground water for the present inhabitants. By careful planning, supplies of ground water for irrigation or domestic purposes could be developed to keep pace with the increase of population, with industry, and farming. To bring surface waters to a region where the population is grouped in small scattered centres, as is the case at present in most of Surrey Municipality except Whalley and White Rock, involves the construction of large and costly mains and a high cost per capita. Under such conditions the use of ground water may be much more economical. In a densely populated area, on the other hand, the per capita cost of surface water supply is relatively low.

The writers believe that the ground water should be fully and properly developed during the initial growth of Surrey Municipality, and that only after the municipality is densely populated with large urban areas should surface water be brought in by mains. The ground water could then be used for irrigating farms, and for industrial cooling and processing.

CHAPTER VI

QUALITY OF WATER

The chemical character of the ground water in Surrey Municipality is indicated by the analyses of 8 samples given in the table on page 46 . These samples were collected from different water-bearing formations and are believed to represent the various types of water available to wells and springs in the municipality. The analyses were made by the Mines Branch, Department of Mines and Technical Surveys, Ottawa.

CHEMICAL CONSTITUENTS IN RELATION TO USE

The following discussion has been adapted from publications of the Geological Survey of Canada, the United States Geological Survey, and the State Geological Survey of Kansas.

Dissolved Solids (residue on evaporation). As ground water slowly percolates through the rocks near the earth's surface, it dissolves part of their constituent elements. The kind and quantity of these elements present in the water determine its suitability for various uses. Water containing less than 500 parts per million of dissolved solids is considered to be most satisfactory for domestic use. People may, through long use, become accustomed to water containing slightly more than 1,000 parts per million of dissolved solids, but generally such water is unsuitable for most uses.

Only two of the samples contained dissolved solids in excess of 500 parts per million, but both were well below the critical 1,000 parts per million point. One sample came from the lower Nicomekl Valley and is believed to represent the ground water from sand lying about 150 feet below sea-level in the lower Nicomekl and Serpentine Valleys. The other sample came from a sand about 135 feet below sea-level in the lower Campbell Creek Valley, and is believed to represent the ground water in the valley at this depth. The ground water along the slopes of the valley walls contains less dissolved solids.

Hardness. Hardness of water is caused chiefly by dissolved calcium and magnesium compounds. These materials possess a soap-destroying power as they must be precipitated as a sticky curd by the soap before a lather can form. Compounds of calcium and magnesium also form a coating on the insides of vessels in which the water is heated. The hardness of water in its natural state is known as total hardness, and may be divided into carbonate hardness, sometimes called temporary hardness, and non-carbonate hardness, or permanent hardness. Carbonate or temporary hardness, which is caused chiefly by calcium and magnesium bicarbonates, can be removed by boiling. Non-carbonate or permanent hardness, which is caused by the sulphates or chlorides of calcium and magnesium, cannot be removed by boiling but may be reduced by natural or artificial softeners. Water containing more sodium bicarbonate than bicarbonates of calcium and magnesium is soft, even though the total amount of dissolved salts is high.

Water having a total hardness of less than 50 parts per million is considered soft and needs no treatment. A hardness of between 50 and 150 parts per million is satisfactory for most uses, but it increases soap consumption and causes considerable boiler scale. The former may be an important consideration in commercial laundries. Where there is a municipal water supply it is more efficient to soften the water near the source to between 60 and 80 parts per million than for each user to soften his water by the use of excessive soap or special softeners.

The analyses on page 46 indicate that most of the ground water of Surrey Municipality has a total hardness of less than 100 parts per million. One noticeable exception is the water in the White Rock Water Works wells (1-10-1, 1-10-2, 1-10-3), which has a hardness of 115.6 parts per million. The Crescent Beach Water Works water has a hardness of 102.4 parts per million.

Silica (SiO_2). Silica may be derived from almost any sediment found in the Surrey area. It is an objectionable encrustant where the water is used for steam boilers. The ground waters sampled, however, contained a maximum of 30.8 parts per million of silica, which should not cause significant trouble to boilers.

Calcium (Ca). Water containing carbon dioxide dissolved from the air and soil attacks calcium carbonate more readily than the silicate minerals. The calcium is dissolved and held in solution by percolating ground waters as calcium bicarbonate. The chief sources of calcium for most water are limestone, gypsum, and dolomite, but it is believed that the ground water of Surrey Municipality obtains its dissolved calcium from the glacial drift as the glaciers eroded and transported limestone to the municipality from areas outside the lower Fraser Valley. Another source of calcium may be fossil beds that contain shells with a high calcium content. These occur in silts and clays in the unconsolidated deposits of the municipality. However, the fact that all waters tested showed about the same amount of dissolved calcium suggests that this element comes predominantly from limestone disseminated throughout the glacial deposits of the area.

Magnesium (Mg). The usual source of magnesium in ground water is dolomite. Water containing carbon dioxide will dissolve calcium and magnesium in about the same proportion as they are in the original rock, commonly 30.4 parts of calcium to 21.7 parts of magnesium. It will be noted, however, that the samples do not show such a ratio between these two elements. This, plus the fact that dolomite is not found in the mountain areas bordering the lower Fraser Valley, strongly suggests that the magnesium does not come from this source. Another probable source is sea water.

Sodium (Na). Sodium salts such as sodium chloride, sodium sulphate, and sodium bicarbonate are found in all natural water. Their sources are rock salt interbedded with or disseminated through sedimentary bedrock formation, sea water either directly or from that enclosed in sediments of marine origin, feldspars, and certain other sodium bearing minerals. Moderate quantities of sodium salts have little effect upon the suitability of a water for ordinary uses, but water containing sodium in excess of 100 parts per million must be used with care in steam boilers to prevent foaming.

The highest sodium content was found in well No. 1-25-1, which contained 232.0 parts per million. This particular well was reported to have tapped a water-bearing sand 150 feet below sea-level. The water from this well is believed to be representative of the ground water beneath the lower Nicomekl and Serpentine Valleys to this depth. Water from a deeper aquifer such as that tapped by well No. 1-34-2 at 210 feet below sea-level, contained 164 parts per million sodium. Ground water from the lower Campbell Creek Valley is also relatively high in sodium, as represented by well No. 7-8-1, which contained 176 parts per million of sodium. From the above it would seem advisable to avoid obtaining industrial water from beneath the lower valleys of Nicomekl, Serpentine, and lower Campbell Creeks.

Potassium (K). Potassium is derived originally from alkaline feldspars and micas. It is of minor significance although beneficial to plants when water containing it is used for irrigation.

Sulphates (SO4). The main source of sulphate in ground water is gypsum ($CaSO_4 \cdot 2H_2O$) and metallic sulphides such as pyrite (FeS2). The latter is believed to be the chief source of the sulphate in the ground waters of Surrey Municipality. Above 350 p.p.m. sulphate is objectionable for irrigation and industrial uses.

Chloride (Cl). Chloride is derived from organic materials or from sea water either directly or indirectly. Chlorides in excess of 300 parts per million impart a salty taste to water. The chloride content of the samples of ground water analysed is below the critical amount that would adversely affect the water for domestic, irrigation, and industrial use.

Nitrate (NO_3). Nitrate is of minor importance in the use of ground water. Relatively large amounts may represent pollution by sewage, or drainage from barnyards, fertilized fields, or leguminous crops such as alfalfa. It is suggested that a bacteriological test be made of water showing a large nitrate content if it is to be used for domestic purposes. The analyses of the samples of ground water taken in Surrey Municipality show that nitrate is either absent or in quantity of less than 1 part per million. It is accordingly assumed that the drilled wells of the municipality are relatively free from pollution.

Carbonate(CO_3). Carbonate forms a large percentage of the solid compounds held in solution by the average ground water. The two chief sources are the decomposition of feldspar and the solution of limestone by water containing dissolved carbon dioxide. The carbonate content is indicated in the analyses table as alkalinity and has been discussed in the section on hardness.

Bicarbonate (HCO_3). Carbon dioxide dissolved in water renders the insoluble calcium and magnesium carbonates soluble as bicarbonates. Boiling reverses the process by changing the bicarbonates into insoluble carbonates that precipitate out of solution and may form a coating on the sides of cooking utensils.

Analyses of Well Waters from Surrey Municipality, B.C.

Location and No. of well	Dissolved solids	SiO_2 (col)	Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	Hardness as $CaCO_3$		
											Total	CO_3	Non-CO_3
1-10-NE.,1	182.0	16.8	29.0	10.5	80.0	2.9	134.2	12.8	21.0	0	115.6	115.6	0
1-12-SE.,5	328.0	30.8	10.0	0	127.0	4.0	305.0	9.1	10.0	0	25.0	25.0	0
1-24-NE.,1	140.0	13.2	29.0	2.8	6.8	1.8	119.6	6.2	1.0	0	83.9	83.9	0
1-25-NE.,1	740.0	26.8	24.0	0	232.0	10.0	334.3	43.2	206.0	0	59.9	59.9	0
1-34-NW.,2	490.0	20.8	20.1	3.0	164.0	10.2	302.6	21.4	104.0	0	62.3	62.3	0
7-8--NE.,1	652.0	10.4	22.0		176.0	9.2	236.7	33.8	167.0	0.7	54.9	54.9	0
8-4 -NW.,3	90.0	6.0	20.0	1.1	4.3	1.0	73.2	2.5	0.5	0	54.4	54.4	0
8-31-SW.,4	314.0	28.0	21.0	0	82.0	6.3	217.2	39.5	28.0	0	52.4	52.4	0

All figures are in parts per million.

Errata to Accompany Well Records
of Surrey Municipality, B.C.

Page 1. Tp. 1, Sec. 17, Well Nos. 3 and 4; for S.W. read N.W.

" 1. Tp. 1, Sec. 17, Well No. 5; for S.W. read N.E.

" 1. Tp. 1, Sec. 34, Principal Aquifer; under Depth to top;
for 250 read 238.

" 2. Tp. 2, Sec. 6, Well Nos. 2 and 3; for S.W. read N.W.

" 4. Tp. 2, Sec. 27, Well No. 14, Description of Well, under Type;
for Dug read Spr., and under Static
Level, for -1 read 0.

" 5. Tp. 2, Sec. 36, Well No. 2, Yield; for 380 read 1380.

" 7. Tp. 8, Sec. 8, Well No. 2, Description of Well, under Static Level;
for -2 read 0.

" 8. Tp. 8, Sec. 17, Well No. 4, Description of Well, under Depth;
for 3 read ?.

" 8. Tp. 8, Sec. 20, Well No. 1, Description of Well, under Depth;
for 20 read 25.

" 11. Blk. 5N, Rge. 1 W, under Lot,; for 24 read 23.

" 11. Blk. 5N, Rge. 1 W, Lot 35, Well No.; for 1 and 2 read 3 and 4
respectively.

" 11. Blk. 5N, Rge. 1 W, Lot 36, Well No.; for 1 read 2.

COMPILATION OF WELL DATA

The following information pertains to the Well Records of Surrey

Municipality:

Description of well:

Type of well

Bor. - bored
Drl. - drilled
Drn. - driven
Dug - dug or hand augered
Spr. - spring

Type of casing

Conc. - concrete
Iron - standard galvanized iron pipe
Steel - standard black pipe
Wood - wood cribbing

Collar elevation

The elevations are with reference to mean sea level, and are believed accurate to within 5 feet.

Static level

The static level is the level of the water with respect to the ground level at the collar of the well. Where the level is positive the water rises above the ground and the well is a flowing artesian.

Principal aquifers:

Depth to top

The depths are the reported depths to the top of the main water-bearing deposits, and are believed to be accurate within 5 feet.

Character of material

The character of the material is that observed by the writers or that reported and believed reliable.

Water:

Use

Dom. - domestic
Ind. - industrial
Irr. - irrigation
Pub. - public
Stk. - livestock

Formations penetrated:

These are the deposits which are believed to be penetrated by the well.

A. Salish group sediments.

B. pre-Salish group sediments. (These are believed to be mainly Cloverdale, but may include some older sediments.)

C. Bose gravel.

D. Sunnyside sand.

E. Alouette gravel.

F. Cloverdale sediments.

G. Newton stony clay.

H. Abbotsford outwash.

I. Surrey till.

J. pre-Vashon group sediments, exclusive of Colebrook gravel.

K. Semiamu sediments.

L. Sapperton sediments.

N. Colebrook gravel. (Much of the gravel logged as Colebrook may be proven by deeper wells to be Semiamu).

O. Nicomekl silt.

P. Point Grey sediments.

Q. Quadra group sediments.

R. Lynn outwash.

S. Sisters varved clay.

T. Seymour till.

U. Seymour group sediments.

V. pre-Seymour group sediments.

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		FORMATIONS PENETRATED	YIELD	REMARKS
Tp.	Sec.	¼		Type	Casing, diam. (inches)	Depth (ft.)	Collar Elev. (ft.)	Static Level (ft.)	Depth to top (ft.)	Character of material	Formation	Quality	Use		(gals /hr)	
1	1	NW.	1	Drl.	Steel 6	105	20	-9	105	Sand	pre-Vashon	Salty	Dom.	D.G.J.	---	Log inferred. Possible sea-water contamination.
1	8	NW.	1	"	" 4	200	285	-100	70	"	Colebrook	---	"	C.D.G.I.N.	---	Pumps sand. Water unconfined.
1	8	NW.	2	"	" 4	128	225	-80	126	"	"	---	"	C.D.G.I.N.Q.	---	Confined under 6' clay.
1	10	SW.	1	"	Iron 6	175	10	+8	53;160	Sand,gravel	pre-Vashon	Clear,good	Pub.	C.I.J.N.	7500	White Rock Water Works.
1	10	SW.	2	"	" 8	210	13	+2	60;127;161	" "	" "	" "	Pub.	C.I.J.N.	7500	" " " "
1	10	SW.	3	"	" 8	208	15	+1	51;112;160	" "	" "	" "	Pub.	C.I.J.N.	7500	" " " "
1	10	NE.	4	"	" 2	80	130	-2	80	Gravel	" "	Clear,soft	Dom.	C.G.I.J.N.	---	Confined water.
1	12	NE.	1	"	" 4	54	119	+3	54	"	Colebrook	" "	"	C.I.N.	1200	
1	12	NE.	2	Dug	Conc.84	25	100	0	25	"	"	" "	"	I.N.	---	
1	12	SE.	3	Drl.	Iron 3	110	70	+3	110	Sand	---	" "	"	D.G. ?	240	Shells at El.20
1	12	SE.	4	"	" 2	55	69	+4	46	Pea-gravel	---	" "	"	D.G. ?	230	" " El.14
1	12	SE.	5	"	" 6	118	153	-58	80	Sand,gravel	Colebrook	" "	"	C.D.G.I.N.	350	
1	13	SE.	1	"	" 5	133	230	-100	130	" "	pre-Vashon	" "	"	G.I.J.N.	280	Water below 100' of clays.
1	13	SW.	2	Dug	--- 72	43	210	-40	16	Silty stony-clay	Newton	Soft	"	G.	---	Surface water table. Seasonal fluctuations.
1	16	SW.	1	"	--- 48	11	315	-5	9	Pebbly silty clay	"	"	"	D.G.	---	Water table perched under large flat area.
1	17	SW.	1	Drl.	" 4	80	250	-75	75	Sand,gravel	Colebrook	Fairly hard	Dom. Irr.	C.D.G.I.N.	650	
1	17	SW.	2	"	" 4	106	276	-76	104	Sand	Quadra	"	Dom.	C.G.I.K.L.Q.	350+	
1	17	SW.	3	"	" 4	167	230	-30	146	Gravel	Seymour	Clear,good	Irr.	C.G.I.K.L.Q.U.	---	
1	17	SW.	4	"	" 4	132	292	-92	131	Fine sand	pre-Vashon	---	Dom.	C.D.G.I,J.,N.	---	Abandoned.
1	17	SW.	5	"	--- 4	107	280	---	---	---	---	---	---	C.D.G.I.N.	---	Dry hole. Not deep enough.
1	18	NW.	1	"	Iron 4	140	110	-30	---	---	---	Clear,good	Dom.	---	---	Log unknown.
1	18	NW.	2	Dug	Conc.36	20	10	-10	20	---	---	" "	"	---	---	" "
1	19	SE.	1	Drl.	Iron 4	45	190	-15	---	---	---	" "	"	---	---	" "
1	19	SW.	2	"	" 4	140	150	-120	---	---	---	" "	"	---	---	" "
1	20	NW.	1	"	" 6	30	0	+1	25	Sand,gravel	Colebrook	" "	"	A.C.F.I.N.	2000	Pumped. Supplies 8 houses.
1	21	NE.	1	"	" 4	200	270	---	---	---	---	---	---	C,F,G,I,N	---	Dry hole.
1	22	NW.	1	Dug	--- 48	9	125	-6	8	Sand	Colebrook	Clear,good	Dom.	G.I.N.Q.	---	No seasonal fluctuation.
1	23	NE.	1	"	Wood 60	15	65	-12	0	"	Quadra	" "	"	D.Q.	---	" " "
1	23	NE.	2	"	" 60	8	150	0	8	Gravel	Colebrook	" "	"	C.I.N.	---	Slight seasonal fluctuation.
1	23	NW.	3	Drl.	Iron 3	120	138	-60	120	"	Quadra	" "	"	G.N.Q.	---	
1	24	NE.	1	Spr.	--- ---	0	48	0	0	Sand	Quadra	" "	Pub.	Q.	7500	Kensington Water Works. At foot of Surrey till slope.
1	24	NW.	2	Dug	--- 60	11.5	160	-5	11	Gravel	Colebrook	" "	Dom.	C.I.N.	---	
1	24	NW.	3	Drl.	Iron 4	60	50	-2	60	Sand	Quadra	" "	"	D.G.Q.	---	Shells at El.-10
1	25	NE.	1	"	" 2	164	10	+12	160	"	Cloverdale	Some salt	"	A.B.	30	Log sketchy.
1	25	SE.	2	"	" 2	215	15	+14	215	"	"	Hard	"	A.B.	30	" "
1	25	SE.	3	"	" 2	290	17	+16	290	"	"	"	"	A.B.	30	" "
1	26	NW.	1	Drl.	" 4	300+	10	+10	---	---	---	---	"	---	20	Log unknown.
1	34	NW.	1	"	" 2½	238	-2	+2	250	Sand	Cloverdale	Trace salt	"	A,B.	20	Log sketchy.
1	34	NW.	2	"	" 3	228	10	+10	220	"	"	Clear,good	"	A,B.	3000	Log sketchy. Shells at El.-205.

REPRESENTATIVE WELL RECORDS OF SURREY MUNICIPALITY, NEW WESTMINSTER MAP-AREA, BRITISH COLUMBIA

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		FORMATIONS PENETRATED	YIELD	REMARKS
Tp.	Sec.	¼		Type	Casing, diam. (inches)	Depth (ft.)	Collar Elev. (ft.)	Static Level (ft.)	Depth to top (ft.)	Character of material	Formation	Quality	Use		(gals /hr)	
2	1	NW.	1	Drl.	Iron 2	256	5	+10	241	Sand, gravel	Cloverdale	Hard	Dom.	A,B.	170	Shells reported in similar wells at El.-70,-120,-220
2	2	SW.	1	"	" 4	220	10	+13	217	Sand	"	Fairly hard	Dom. Stk.	A,B.	100	Log sketchy.
2	3	SE.	1	"	" 2	245	12	+14	245	"	"	Trace salt	Dom.	A,B.	200	" "
2	3	NW.	2	Dug	--- 48	42	223		26	"	Quadra	---	"	G,N,Q.	---	Intermittent Well.
2	4	NE.	1	Spr.	--- 48	4	25	0	3	"	"	Soft	"	C,Q.	---	
2	6	NE.	1	Dug	Conc.48	45.5	167	-43	---	Sand, gravel	Colebrook	Fairly hard	"	C,G,I.N.	---	Log not complete.
2	6	SW.	2	"	" 36	19	38	-16	0	" "	"	Fairly hard	"	N.	---	
2	6	SW.	3	Spr.	--- 36	2	95	0	0	" "	"	Fairly hard	"	N.	---	
2	9	NE.	1	Dug	Conc.60	23	159	-6	23	Gravel	"	Soft	"	G,N.	---	Slight seasonal fluctuation.
2	10	NE.	1	"	" 36	9	78	-6	0	Sand, gravel	"	"	"	N.	50	No shortage in 30 yrs.
2	10	NE.	2	"	" 48	12	167	-8	12	" "	"	"	"	N.	---	No seasonal fluctuations.
2	10	NW.	3	"	--- 48	17	160	-11	9	" "	"	"	"	G,I,N.	---	
2	10	NE.	4	"	--- 48	10	165	-7	9	" "	"	"	"	G,I,N.	---	
2	11	SE.	1	"	--- 48	32	48	-18	30	Sand	Quadra	"	"	C,G,N.Q.	---	
2	11	SW.	2	"	Conc.48	22	36	-15	0	Sandy clay	Newton	"	"	G.	50	
2	11	SW.	3	Spr.	--- ---	0	55	0	0	Sand	Quadra	"	"	Q.	50	
2	11	NW.	4	Dug	Conc.40	15	70	-10	10	"	"	"	"	C,G,Q.	---	
2	12	NE.	1	Drl.	Iron 2	30	82	-30	30	"	"	"	"	---	---	
2	12	SE.	2	Dug	--- 72	23	75	-11	23	Gravel	Colebrook	"	"	G,N.	---	Seasonal fluctuations.
2	12	SE.	3	Drl.	Iron 5	647	95	-16	605	Sand	---	"	Pub.	---	---	Surrey Centre School.
2	12	SE.	4	Dug	--- 72	6	50	0	5	Gravel	Colebrook	"	Dom.	G,I,N.	---	
2	12	SE.	5	"	--- 48	7	8	-3	6	"	"	"	"	G,I,N.	---	
2	12	SW.	6	Drl.	Iron 2	170	5	+10	---	---	---	Fairly hard	"	---	---	
2	12	NW.	7	Dug	Wood 96	8	15	-8	0	Sand, gravel	Colebrook	Soft	"	N.	500	
2	12	NE.	8	"	" 48	23	127	-20	15	" "	"	"	"	G.N.	---	
2	12	NW.	9	Drl.	Iron 3	160	10	+12	160	Gravel	"	"	Dom., Stk.	A,D,F,I,N.	240	Shells at El.-80'
2	12	NW.	10	"	" 4	32	10	+9	32	"	"	Hard	Dom., Stk.	I,N.	1800	Shells at El.0'
2	14	SE.	1	"	" 3	120	10	+4	120	"	"	Soft	Dom., Stk.	I,N.	90	Shells at El.-50'
2	14	SW.	2	Dug	Conc.48	29	30	-14	29	"	"	"	Dom., Stk.	G,I,N.	300	
2	14	SW.	3	"	" 48	21	28	-10	21	"	"	"	Dom.	G,I,N.	---	
2	15	NE.	1	Spr.	Wood 48	1	40	0	0	---	---	"	"	---	---	Bog Area.
2	15	SE.	2	Dug	" 60	16	48	-11	11	Gravel	Colebrook	"	"	G,I,N.	---	
2	15	SW.	3	Drl.	Iron 1	60	50	+5	50	Sand	---	"	Dom., Stk.	G,I.	100	
2	15	NW.	4	Dug	Wood 48	20	225	-16	20	"	Quadra	"	Dom., Stk.	I,N,Q.	500	Cannot pump dry.
2	17	NE.	1	Drl.	Iron 5	38	188	-12	20	Gravel	Colebrook	"	Dom.	G,I,N.	2000+	Water unconfined.

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		FORMATIONS PENETRATED	YIELD	REMARKS
Tp.	Sec.	¼		Type	Casing, diam. (inches)	Depth (ft.)	Collar Elev. (ft.)	Static Level (ft.)	Depth to top (ft.)	Character of material	Formation	Quality	Use		(gals /hr)	
2	17	NW.	2	Dug	--- 36	15	290	-10	15	Gravel	Colebrook	Soft	Dom.	G,I,N.	---	
2	20	SE.	1	"	Conc.72	82	258	-80	65	Sand	Quadra	"	Dom., Stk.	C.G.I,K,L,Q.	---	Peat and shells from El. 173-196.
2	21	NE.	1	Bor.	Iron 18	25	85	+7	23	Gravel	Colebrook	"	Dom.	G,I,N.	100	Natural flow.
2	21	NE.	2	Spr.	Wood 48	4	125	0	0	---	---	"	"	---	---	
2	22	NE.	1	"	--- 36	2	10	0	0	---	---	"	"	---	---	
2	22	SE.	2	Dug	--- 48	18	35	-13	0	Clay,silt	Newton	"	"	G.	---	
2	22	SW.	3	"	--- 48	32	192	-30	30	Sand,gravel	Colebrook	"	"	C,G,I,N.	---	Slight Seasonal fluctuations.
2	22	NW.	4	"	--- 36	18	162	-12	18	Sand	"	"	"	C,G,I,N.	---	Slight seasonal fluctuations.
2	22	NW.	5	"	--- 36	20	113	+9	20	Sand,gravel	"	"	"	C,G,I,N.	---	Slight seasonal fluctuations.
2	23	NW.	1	"	Wood 36	7	43	-3	---	---	---	"	"	---	50	
2	24	NE.	1	"	" 36	8	32	0	8	Sand,gravel	Colebrook	"	"	I,N.	100	
2	24	NE.	2	Spr.	" 24	4	31	0	0	" "	"	"	"	N.	---	
2	24	NW.	3	Dug	" 48	20	176	-15	20	" "	"	Hard	"	I,N.	3000	
2	25	NE.	1	Drl.	Iron 4	94	64	-15	90	Sand	Quadra	Soft	"	G,I,Q.	---	Water fluctuates from El. 56 to 49. Shells at El.-26.
2	25	SE.	2	Dug	--- 48	15	140	0	14	"	"	Hard	"	G,Q.	---	Constant yearly.
2	25	NE.	3	"	--- 36	35	216	-33	35	"	---	Soft	Dom., Stk.	---	---	
2	25	SE.	4	"	--- 36	10	144	-6	10	"	Quadra?	"	Dom.	G,I,N,Q.	---	
2	25	SW.	5	"	Wood 48	14	166	-11	14	"	"	"	"	G,Q.	---	
2	25	SW.	6	"	--- 48	16	205	-4	16	Gravel	Colebrook	"	"	G,N.	---	
2	25	SW.	7	"	--- 48	16	205	0	16	"	"	"	"	G,N.	---	
2	25	SW.	8	"	--- 72	21	220	-17	21	"	"	"	"	G,I.N,	---	
2	25	NW.	9	Drl.	Iron 5	46	230	-19	30	"	"	"	"	G,I,N.	700	
2	25	NW.	10	"	" 6	40	210	-15	---	---	---	"	Dom., Stk.	---	---	
2	25	NW.	11	Dug	Conc.36	40	255	-25	---	Sand,gravel	Colebrook	"	Dom.	G,I,N.	---	Generalized log.
2	25	NW.	12	"	" 36	16	190	-14	---	---	---	"	"	---	---	
2	26	SE.	1	"	Wood 48	14	210	-10	12	Sand,gravel	Colebrook	"	"	G,I,N.	---	
2	26	SE.	2	"	Conc.42	18	211	-9	6	" "	"	"	"	G,I,N.	---	
2	26	SE.	3	"	" 36	9	209	---	8	" "	"	"	"	G,N.	---	Well incomplete.
2	26	SE.	4	"	" 36	10	214	-7	10	" "	"	"	"	G,I,N.	---	
2	26	SE.	5	"	--- 48	20	212	-14	20	" "	"	"	"	G,I,N.	---	
2	26	SW.	6	"	Conc.41	28	240	-24	20	" "	"	"	"	G,I,N.	---	
2	26	SE.	7	"	" 72	28	251	-24	25	" "	"	"	Dom., Stk.	G,I,N.	50	
2	26	SE.	8	"	--- 48	38	254	-36	16	" "	"	"	Dom.	G,I,N.	---	
2	26	SW.	9	Spr.	5X15	0	205	0	0	---	---	"	"	---	---	
2	26	SW.	10	Dug	--- 48	11	190	-9	11	Sand,gravel	Colebrook	"	"	G,I,N.	---	
2	26	SW.	11	"	--- 48	12	228	-10	12	Sand	"	"	"	G,I,N.	---	Supplies three houses.
2	26	SW.	12	"	--- 60	10	242	-8	10	"	"	"	Dom., Stk.	G,I,N.	50	
2	26	NW.	13	"	--- 36	38	261	-36	---	Sand,gravel	"	"	Dom., Stk.	G,I,N.	50	Log incomplete.

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		FORMATIONS PENETRATED	YIELD	REMARKS
Tp.	Sec.	¼		Type	Casing, diam. (inches)	Depth (ft.)	Collar Elev. (ft.)	Static Level (ft.)	Depth to top (ft.)	Character of material	Formation	Quality	Use		(gals /hr)	
2	26	NE.	14	Drl.	Iron 6	75	271	-61	50,75	Sand,gravel	Quadra	Soft	Dom., Stk.	B,G,I,K,L,Q.	---	
2	26	NW.	15	Dug	Conc.48	25	265	-14	12	" "	Colebrook	"	Dom.	G,I,N.	---	
2	26	NE.	16	"	" 48	52	295	-49	10	" "	"	"	"	C,G,I,N.	---	
2	26	NW.	17	"	" 42	37	309	-35	18	" "	"	"	"	C,G,I,N.	50	
2	26	NE.	18	"	Wood 36	80	309	-77	22	" "	"	"	"	C,G,I,N.	---	
2	27	NE.	1	"	--- 48	13	197	-10	---	---	---	"	Dom., Stk.	---	---	
2	27	NE.	2	"	--- 48	24	168	-19	---	Sand,gravel	Colebrook	"	Dom., Stk.	G,I,N.	---	Log incomplete.
2	27	NE.	3	"	--- 48	13	133	-6	---	---	---	"	Dom., Stk.	---	---	
2	27	NE.	4	"	--- 48	20	212	-15	---	---	---	"	Dom.	---	---	
2	27	SE.	5	"	--- 48	16	130	-10	---	---	---	"	Dom., Stk.	---	---	
2	27	SE.	6	"	--- 48	18	67	-15	---	Sand,gravel	---	Hard	Dom., Stk.	---	---	
2	27	SE.	7	"	--- 60	24	93	-18	24	" "	Colebrook	Soft	Dom., Stk.	G,I,N.	---	Supplies three homes.
2	27	SW.	8	"	--- 48	23	90	-20	---	" "	"	"	Dom., Stk.	G,I,N.	---	Log incomplete.
2	27	SW.	9	"	--- 48	15	93	-10	---	" "	"	"	Dom., Stk.	G,I,N.	---	
2	27	SW.	10	"	--- 36	18	110	-14	15	" "	"	"	Dom.	G,I,N.	---	
2	27	SW.	11	Drl.	Iron 3	50	142	-21	50	" "	"	"	Dom., Stk.	G,I,N.	---	
2	27	SW.	12	Dug	--- 36	17	140	-7	9	" "	"	"	Dom., Stk.	G,I,N.	---	
2	27	SW.	13	"	Wood 60	12	157	-7	---	" "	"	"	Dom., Stk.	G,I,N.	---	Log incomplete.
2	27	NW.	14	"	--- 36	3	173	-1	0	" "	"	"	Dom., Stk.	N.	---	Spring.
2	27	NE.	15	"	--- 36	9	208	-3	---	" "	"	"	Dom., Stk.	G,I,N.	---	Log incomplete.
2	28	NE.	1	"	Wood 60	10	164	-8	9	Sand	Quadra	"	Dom., Stk.	G,I,N,Q.	---	
2	28	SE.	2	"	" 48	16	143	-2	14	Sand,gravel	Colebrook	"	Dom., Stk.	G,I,N.	---	
2	28	SE.	3	"	" 48	23	103	-4	23	" "	"	"	Dom., Stk.	D,G,K,L.	---	
2	32	NE.	1	Drl.	Iron 4	70	217	---	---	Gravel	"	---	---	G,I,N.	Dry	
2	33	SE.	1	Dug	Wood 48	33	252	-18	30	"	"	Soft	Dom., Stk.	G,I,N.	---	
2	33	SE.	2	"	--- 48	33	245	-27	33	"	"	"	Dom.	G,I,N.	---	
2	33	SE.	3	"	--- 48	20	230	-12	11	"	"	"	"	G,N.	---	
2	33	SE.	4	"	Conc.60	14	205	-4	13	"	"	"	"	G,I,N.	---	
2	34	SE.	1	"	" 48	35	314	-31	32	"	"	"	Dom., Stk.	G,I,N.	---	
2	34	SE.	2	"	--- 48	16	251	-3	12	"	"	"	Dom., Stk.	G,I,N.	---	
2	34	SW.	3	"	--- 48	8	215	-4	8	"	"	"	Dom.	G,I,N.	---	
2	34	SW.	4	"	--- 48	15	212	-10	6	"	"	"	"	G,I,N.	---	

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		FORMATIONS PENETRATED	YIELD	REMARKS
Tp.	Sec.	¼		Type	Casing, diam. (inches)	Depth (ft.)	Collar Elev. (ft.)	Static Level (ft.)	Depth to top (ft.)	Character of material	Formation	Quality	Use		(gals /hr)	
2	34	SW.	5	Dug	Conc.48	85	295	-82	85	Sand	Quadra	Soft	Dom., Stk.	G.I.K.L,N,Q.	---	
2	35	NE.	1	"	" 60	30	222	-25	30	Sand,gravel	Colebrook	"	Dom.	G,I,N.	---	Supplies three houses.
2	35	NE.	2	"	--- 48	16	224	-10	16	" "	"	"	Dom., Stk.	C,G,N.	---	
2	35	SE.	3	Drl.	Iron 4	50	248	-29	40	" "	"	"	Dom.	C,G,I.N.	---	
2	35	SE.	4	Dug	--- 48	69	290	-64	20	" "	"	"	Dom., Stk.	C,G,I,N.	---	
2	35	SE.	5	"	Conc.48	20	228	-12	20	" "	"	"	Dom., Stk.	G,I,N.	---	
2	35	SE.	6	"	" 48	70	298	-60	20	" "	"	"	Dom.	C,G,I,N.	---	Supplies three houses.
2	35	SE.	7	"	" 42	66	302	-60	25	" "	"	"	Dom., Stk.	C,G,I,N.	---	
2	35	SE.	8	"	Wood 42	67	298	-64	67	" "	---	"	Dom.	C,G,I,J.	---	
2	35	SW.	9	"	Conc.36	28	322	-23	23	" "	Colebrook	"	"	C,G,I.N.	---	
2	35	SW.	10	"	" 72	38	323	-30	28	" "	Semiamu	"	Dom., Stk.	C,G,I,K,L.	---	Sediments. Seasonal fluctuations.
2	35	SW.	11	"	" 36	63	288	-60	---	" "	---	"	Pub.	---	---	Also supplies 3 houses in summer.
2	35	NE.	12	"	--- 48	15	240	-10	---	" "	---	"	Dom.	---	---	Log incomplete.
2	36	NE.	1	Drl.	Iron 2	360	40	+8	360	Sand	Quadra	"	Dom., Stk.	D,F,G,K,L,Q.	100	Natural flow.
2	36	SE.	2	"	" 3	235	34	+10	70	"	"	"	Dom., Stk.	D,F,G,K,L,Q.	380	" "
2	36	SE.	3	Dug	Wood 36	21	46	0	19	Sand,gravel	Colebrook	"	Dom., Stk.	D,F,N.	---	
2	36	SE.	4	"	--- 60	16	67	-12	15	" "	"	"	Dom., Stk.	G,I,N.	---	
2	36	SE.	5	Spr.	Wood 12	1	115	0	0	" "	"	"	Dom., Stk.	N.	---	
2	36	SW.	6	Dug	" 36	8	132	-6	---	" "	"	"	Dom., Stk.	---	---	Log incomplete.
2	36	SW.	7	"	" 72	32	215	-28	32	Sand	---	"	Dom.	---	---	" "
2	36	SW.	8	"	" 72	35	184	-6	35	---	---	"	Dom., Stk.	---	---	" "
2	36	NW.	9	"	" 48	22	176	-17	19	Sand,gravel	Colebrook	"	Dom.	G,I,N.	---	
2	36	NW.	10	"	--- 36	6	152	-1	---	Sand	---	"	"	---	---	
7	4	NW.	1	Drl.	Iron 2	319	45	+15	---	Gravel	---	"	Dom., Stk.	---	250	Natural flow. Log incomplete.
7	4	NE.	2	Drn.	" 2	61	95	+10	60	"	Seymour	"	Dom.	D.F.G.K.Q.U.	---	
7	6	NW.	1	Drl.	" 2	270	50	+5	265	"	Seymour	"	"	D.F.G.K.Q.U.	500	Natural flow.
7	7	SW.	1	"	" 2	200	60	+18	200	Sand	Quadra	"	Dom., Stk.	D.F.G.K.L.Q.	500	" "
7	7	NW.	2	"	" 10	303	60	+8	275	"	Seymour	"	Pub.	D.F.G.K.L.M.O.P.U.	600	Surrey Municipality. Natural flow.
7	7	NW.	3	Dug	Wood 36	15	100	0	15	Gravel	Colebrook	"	Dom.	H.G.I.N.	---	
7	7	NE.	4	Drl.	Iron 4	51	96	-8	32	Sand	Quadra	"	"	G.I.Q.	---	
7	8	NE.	1	"	" 2	250	51	+15	185	"	"	"	"	D.F.G.K.L.Q.	300	Natural flow. Community Hall.
7	8	NW.	2	"	" 2	115	78	+3	60	"	"	"	Dom., Stk.	D.F.G.K.L.Q.	200	Natural flow.

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		FORMATIONS PENETRATED	YIELD	REMARKS
Tp.	Sec.	¼		Type	Casing, diam. (inches)	Depth (ft.)	Collar Elev., (ft.)	Static Level (ft.)	Depth to top (ft.)	Character of material	Formation	Quality	Use		(gals /hr)	
7	9	SE.	1	Drn.	Iron 2	75	100	+3	---	---	---	Soft	Dom.	---	15	Log incomplete.
7	9	SE.	2	Drl.	" 2	95	160	+5	60	Sand	Quadra	"	"	D.G.Q.	---	Peat reported in aquifer.
7	9	NW.	3	"	" 2	310	57	+15	250	"	"	"	"	D.F.Q.	---	
7	10	NW.	1	Drn.	--- 36	30	141	-11	0	Sand, gravel	Campbell	"	Dom., Stk.	H.	---	
7	15	NE.	1	"	Iron 2	22	165	-18	0	" "	"	"	Dom., Stk.	H.	---	
7	15	SE.	2	Dug	--- 48	22	185	-14	0	" "	"	"	Dom., Stk.	H.	---	
7	16	SE.	1	"	Conc. 30	30	134	-10	0	" "	"	"	Dom., Stk.	H.	---	
7	16	SE.	2	Spr.	--- --	---	92	0	0	Sand	"	"	Dom., Stk.	H.	---	
7	17	SE.	1	Drl.	Iron 5	78	90	-30	40	Sand, gravel	Semiamu	"	Dom., Stk.	C.G.I.K.	450	Semiamu sediments.
7	18	SE.	1	Dug	Wood 48	10	116	-4	7	Sand	Quadra	"	Dom., Stk.	C.G.Q.	---	
7	20	SW.	1	Drl.	Iron 4	88	160	-30	40	Sand, gravel	Colebrook	"	Dom.	C.G.I.N.	250	
7	21	NW.	1	Spr.	Wood 24	2	84	0	0	Sand, gravel	Abbotsford	"	"	H.	---	
7	21	NE.	2	Drn.	Iron $1\frac{1}{2}$	19	150	-15	0	" "	"	"	"	H.	---	
7	22	NE.	1	Drn.	Iron $1\frac{1}{4}$	24	164	-15	0	" "	"	"	Dom., Stk.	H.J.	---	Log incomplete.
7	22	SE.	2	"	" 2	24	164	-14	0	" "	"	"	Dom., Irr.	H.	---	
7	22	SE.	3	"	" $1\frac{1}{4}$	15	157	-14	0	" "	"	"	Dom., Irr.	H.	---	
7	22	NW.	4	"	" 2	12	153	-10	0	" "	"	"	Dom., Irr.	H.	---	
7	22	NW.	5	Dug	Conc. 36	10	154	-9	0	" "	"	"	Dom., Irr.	H.	---	
7	27	SE.	1	"	--- 36	25	164	-12	0	" "	"	"	Dom., Stk.	H.	---	
7	28	SW.	1	Spr.	Reservoir	0	67	0	0	---	---	"	Dom., Stk.	---	---	Log incomplete.
7	29	NE.	1	Drl.	Iron 2	280	20	+6	200	Coarse sand	Quadra	"	Dom., Stk.	D.F.K.L.Q.	---	" "
7	29	SE.	2	"	" 2	140	35	+1	---	" "	pre-Vashon	"	Dom., Stk.	D.F.K.L.Q.	---	" "
7	29	NW.	3	"	" 2	330	10	+3	300	Gravel	" "	"	Dom.	A.F.I.J.	25	
7	30	SW.	1	"	" 2	97	22	+6	97	Sand	---	"	Dom., Stk.	---	---	Log incomplete.
7	32	SE.	1	"	" 2	---	---	+5	---	---	---	"	Dom., Stk.	D.F.I.J.	---	" "
7	33	NE.	1	Spr.	--- 72	2	25	0	---	---	---	"	Dom., Stk.	D.	---	
7	33	NE.	2	Dug	Wood 36	16	30	-11	16	Sand	pre-Vashon	"	Dom.	D.F.Q.	---	
7	34	NE.	1	"	Conc. 36	12	110	-5	0	Sand, gravel	Abbotsford	"	Dom., Stk.	H.	---	
7	34	NE.	2	"	Wood 60	40	110	-36	0	" "	"	"	Dom., Stk.	H.	---	

REPRESENTATIVE WELL RECORDS OF SURREY MUNICIPALITY, NEW WESTMINSTER MAP-AREA, BRITISH COLUMBIA

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		FORMATIONS PENETRATED	YIELD	REMARKS
Tp	Sec.	¼		Type	Casing, diam. (inches)	Depth (ft.)	Collar Elev., (ft.)	Static Level (ft.)	Depth to top (ft.)	Character of material	Formation	Quality	Use		(gals /hr)	
7	34	NE.	3	Dug	Wood 30	30	140	-31	0	Sand, gravel	Abbotsford	Soft	Dom., Stk.	H.	---	
7	34	SE.	4	Drn.	Iron 4	45	140	-40	0	" "	"	"	Dom., Stk.	H.	---	Minor irrigation.
7	34	SE.	5	Dug	Conc.36	51	140	-48	51	Sand	pre-Vashon	"	Dom., Irr.	H.G.J.	---	Peat in sand at El.89.
7	34	NW.	6	"	Wood 48	50	45	-5	---	---	---	"	Dom., Stk.	---	---	Log incomplete.
8	3	NE.	1	Drl.	Iron 1½	311	25	+15	300	Gravel	pre-Vashon	"	Dom., Stk.	F.N.J.	100	
8	3	SE.	2	"	" 4	150	40	+1	---	---	---	"	Dom., Stk.	---	360	Log incomplete.
8	3	SE.	3	Dug	Conc.36	9	60	-2	0	Sand	Sunnyside	"	Dom., Stk.	D.	---	Shells at El.52
8	3	SW.	4	Drl.	Iron 4	165	30	+1	100	Sand, gravel	pre-Vashon	"	Dom., Stk.	F.N.J.	50	
8	4	NE.	1	"	" 3	70	30	+1	---	---	---	"	Dom., Stk.	---	200	Log incomplete.
8	4	SE.	2	"	" 4	269	25	+12	---	---	---	"	Dom., Stk.	---	---	" "
8	4	NW.	3	Drn.	" 3	14	38	0	16	Gravel	Colebrook	"	Dom., Stk.	F.I.N.	---	" "
8	4	NE.	4	Dug	Conc.36	19	65	-17	17	"	"	"	Dom., Stk.	F.N.	---	
8	5	NE.	1	Drl.	Iron 4	122	30	-10	121	"	Semiamn	"	Dom., Stk.	F.I.K.	500	Sediments.
8	5	NW.	2	"	" 3	115	10	+8	113	Sand	"	"	Dom., Ind.	F.I.K.	2000	Surrey Co-op.
8	6	NE.	1	"	" 2	150	8	+3	---	"	---	"	Stk.	---	---	Log incomplete.
8	6	SW.	2	"	" 3	247	10	+10	242	"	---	"	Dom., Stk.	---	200	Natural flow. Log incomplete.
8	6	SW.	3	"	" 2	280	5	+14	270	"	---	---	Dom., Stk.	---	100	Natural flow. Log incomplete.
8	7	SW.	1	"	" 2	81	10	+2	65	Gravel	Semiamu	Soft	Dom.	F.K.	---	Semiamu sediments.
8	7	SW.	2	"	" 4	25	10	+2	25	"	"	"	Dom., Stk.	F.I.K.	400+	" "
8	7	SW.	3	Dug	Conc.48	11	8	-2	5	"	Colebrook	"	Dom., Stk.	F.N.	---	
8	7	SW.	4	"	--- 48	22	79	-5	22	"	"	"	Dom.	G.I.N.	---	
8	7	NW.	5	Drl.	Iron 3½	60	66	-15	55	"	"	"	Dom., Stk.	G.I.N.	---	
8	7	NE.	6	Dug	Wood 60	36	60	-18	29	"	"	"	Dom., Stk.	G.N.	---	
8	8	SE.	1	"	Conc.72	23	135	-21	17	Sand	Quadra	"	Dom., Stk.	G.Q.	---	
8	8	SE.	2	Spr.	Wood 24	5	49	-2	0	Gravel	---	"	Dom.	---	---	
8	8	NW.	3	Drl.	Iron 2	75	70	0	---	---	---	"	"	---	10	Natural flow. Log incomplete.
8	8	NW.	4	Spr.	Conc.72	2	78	0	---	Sand	---	"	Dom., Stk.	---	---	

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		FORMATIONS PENETRATED	YIELD	REMARKS
Tp.	Sec.	¼		Type	Casing, diam. (inches)	Depth (ft.)	Collar Elev., (ft.)	Static Level (ft.)	Depth to top (ft.)	Character of material	Formation	Quality	Use		(gals /hr)	
8	8	SW.	5	Drl.	Iron 2	125	15	0	124	Gravel	Semiamu	Soft	Dom., Stk.	F.I.K.	---	Semiamu sediments.
8	9	SE.	1	Dug	Conc.48	17	110	-15	12	"	Colebrook	"	Dom., Stk.	G.I.N.	---	
8	10	NE.	1	Drl.	Iron 2	88	60	0	80	Sand, gravel	Colebrook?	"	Dom., Stk.	F.I.N.	---	
8	10	SE.	2	"	" 1½	197	45	0	194	Coarse sand	pre-Vashon	"	Dom., Stk.	F.I.N.J.	40	Natural flow.
8	10	SE.	3	"	" 2	260	30	+2	160	Gravel	" " ?	"	Dom., Irr.	F.I.N.J.	20	" "
8	10	SW.	4	Drn.	" 2	61	70	+1	60	"	Colebrook	"	Dom., Stk.	F.I.N.	---	
8	10	NW.	5	Dug	Conc.24	22	100	-20	20	Sand, gravel	"	"	Dom., Stk.	F.N.	---	
8	10	NW.	6	Drl.	Iron 3	240	144	-60	---	" "	---	"	Dom., Stk.	---	---	Log incomplete.
8	10	NW.	7	"	" 5	50	132	-44	40	" "	Colebrook	"	Dom., Stk.	G.I.N.	---	
8	15	NW.	1	Dug	Conc.36	45	140	-30	45	Gravel	"	"	Dom., Stk.	C.D.G.I.N.	---	
8	15	SE.	2	"	" 48	27	150	-23	---	"	Colebrook?	"	Dom., Stk.	---	---	Log incomplete.
8	15	SE.	3	Drl.	Iron 3	240	63	0	190	"	pre-Vashon	"	Dom., Stk.	F.I.N.J.	---	" "
8	15	SW.	4	Dug	Conc.48	21	120	-19	21	Sand	Quadra	"	Dom., Stk.	G.Q.	---	" "
8	17	NE.	1	Drl.	Iron 5	131	171	-91	30	"	"	"	Dom., Stk.	G.Q.	---	
8	17	SE.	2	Dug	Conc.60	24	218	-21	24	Gravel	Semiamu	"	Dom., Stk.	G.I.K.	---	Semiamu sediments.
8	17	NW.	3	Drl.	Iron 3	150	12	+4	---	---	---	"	Dom., Stk.	---	15	Natural flow. Log incomplete.
8	17	NW.	4	Dug	Conc.36	3	50	-2	---	Sand?	---	"	Dom., Stk.	---	---	Log incomplete.
8	17	NE.	5	Drl.	Iron 4	90	131	-30	30	Sand	Quadra	"	Dom., Stk.	G.Q.	---	" "
8	18	NE.	1	Drl.	" 2	135	18	+10	---	---	---	"	Dom., Stk.	---	350	Natural flow. Log incomplete.
8	18	SE.	2	"	" 2	150	55	+2	---	---	---	"	Dom., Stk.	---	20	Natural flow. Log incomplete.
8	18	SW.	3	"	" 2	40	52	-3	---	---	---	"	Dom., Stk.	---	---	Log incomplete.
8	18	SW.	4	"	" 6	160	43	+5	---	---	---	"	Dom., Stk.	---	600	Natural flow. Log incomplete.
8	18	NE.	5	"	" 2	101	11	+10	---	---	---	"	Dom., Stk.	---	450	Natural flow. Log incomplete.
8	20	SE.	1	Dug	--- 36	20	110	-20	6	Sand	Quadra	"	Dom., Stk.	G.Q.	---	
8	20	SW.	2	Drl.	Iron 2	150	20	0	---	---	---	"	Dom., Stk.	---	---	Log incomplete.
8	20	NW.	3	"	" 3	325	12	+20	325	Sand	---	"	Dom., Stk.	---	1000	" "
8	21	NE.	1	Dug	--- 48	18	190	-15	18	"	Quadra	"	Dom., Stk.	G.Q.	---	

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		FORMATIONS PENETRATED	YIELD	REMARKS
Tp.	Sec.	¼		Type	Casing, diam. (inches)	Depth (ft.)	Collar Elev., (ft.)	Static Level (ft.)	Depth to top (ft.)	Character of material	Formation	Quality	Use		(gals /hr)	
8	21	NW.	2	Dug	--- 48	30	145	-26	15	Sand	Quadra	Soft	Dom., Stk.	G.Q.	---	
8	21	NE.	3	Spr.	--- 48	1	90	0	0	Sand,gravel	Colebrook	"	Dom., Stk.	G.N.	---	
8	21	NE.	4	Dug	Conc.72	16	110	-12	11	" "	"	"	Dom., Stk.	G.N.	---	
8	27	NE.	1	Drl.	Iron 2	120	75	0	100	Sand	---	"	Dom., Stk.	---	75	Natural flow. Minor irrigation.
8	27	SW.	2	Dug	--- 48	23	148	-20	18	Gravel	Colebrook	"	Dom., Stk.	G.I.N.	---	
8	27	SW.	3	"	--- 48	40	182	-35	40	"	"	"	Dom., Stk.	G.I.N.	---	
8	27	SW.	4	"	Conc.36	8	69	-7	0	Sand	Sunnyside	"	Dom.	D.	---	
8	27	NW.	5	"	" 48	9	50	-7	0	"	"	"	Dom., Stk.	D.	---	
8	28	SE.	1	Drl.	Iron 3	80	90	+1	---	---	---	"	Dom.	---	60	Natural flow. Log incomplete.
8	28	SE.	2	"	" 3	90	35	+4	---	---	---	"	---	---	10	Natural flow. Abandoned.
8	28	SW.	3	"	" 2	345	30	+6	---	---	---	"	Dom., Stk.	---	15	Natural flow. Log incomplete.
8	28	NE.	4	"	" 2	390	20	+3	---	Gravel	---	"	Dom.	---	60	Natural flow. Log incomplete.
8	28	NW.	5	Dug	Conc.24	10	22	-3	8	Sand	---	"	Dom., Stk.	---	---	Log incomplete.
8	28	NW.	6	"	" 36	9	28	-1	9	Gravel	---	"	Dom., Stk.	---	---	" "
8	28	NE.	7	Drn.	Iron 3	12	40	-9	0	Sand	Sunnyside	"	Dom., Stk.	D.	---	
8	29	SE.	1	Drl.	" 2½	390	17	+6	---	---	---	"	Dom., Stk.	---	100	Natural flow. Log incomplete.
8	29	SW.	2	"	" 3	---	20	+25	---	---	---	"	Dom., Stk.	---	2400	Natural flow. Log incomplete.
8	29	SW.	3	"	" 4	260	12	+23	---	---	---	"	Dom., Stk.	---	500	Natural flow. Log incomplete.
8	29	NW.	4	"	" 2	270	10	+20	---	Gravel	---	"	Dom., Stk.	---	---	Log incomplete.
8	29	SE.	5	"	" 2	327	20	+10	327	"	Colebrook?	"	Dom., Stk.	A.F.I.N.	100	Natural flow.
8	30	SW.	1	"	" 6	23	45	0	25	"	"	"	Dom., Stk.	F.N.	---	
8	30	SW.	2	Dug	--- 48	31	75	-20	25	Sand,gravel	"	"	Dom., Stk.	G.I.N.	---	
8	30	SW.	3	"	--- 48	12	140	-3	12	" "	"	"	Dom., Stk.	G.I.N.	---	
8	30	NE.	4	Drl.	Iron 3	90	20	+9	---	---	---	"	Dom., Stk.	---	60	Natural flow. Log incomplete.
8	31	SE.	1	"	" 2½	180	25	+6	---	Sand	---	"	Dom., Stk.	---	120	Natural flow. Log incomplete.
8	31	SW.	2	"	" 2	65	30	+3	60	Gravel	Colebrook?	"	Dom., Stk.	F.N.	100	Natural flow.
8	31	SW.	3	"	" 2	102	29	+5	90	Sand	---	"	Dom., Stk.	F.N.J.	300	Natural flow. Log incomplete.
8	31	SW.	4	"	" 2½	240	26	+8	240	Gravel	pre-Vashon	"	Dom., Stk.	F.N.J.	1500	Natural flow. Log incomplete.

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		FORMATIONS PENETRATED	YIELD	REMARKS
Tp.	Sec.	¼		Type	Casing, diam. (inches)	Depth (ft.)	Collar Elev., (ft.)	Static Level (ft.)	Depth to top (ft.)	Character of material	Formation	Quality	Use		(gals /hr)	
8	31	NW.	5	Dug	--- 48	25	105	-21	5	Gravel	Colebrook	Soft	Dom., Stk.	G.I.N.	---	Static level constant.
8	31	NE.	6	"	Conc.36	31	166	-20	31	"	"	"	Dom., Irr.	G.I.N.	---	
8	32	SE.	1	"	--- 60	30	104	-26	30	Sand,gravel	"	"	Dom.	G.I.N.	---	
8	32	SE.	2	Drl.	Iron 3	212	10	+23	212	Sand	Quadra	"	Dom., Stk.	A.F.G.I.K.L.Q.	1400	Natural flow. Shells at El.-202'.
8	32	SW.	3	"	" 2	85	112	-70	70	Gravel	Colebrook	"	Dom., Stk.	C.G.I.N.	300	
8	33	SE.	1	Dug	--- 36	14	66	-11	0	Sand	Sunnyside	"	Dom.	D.	---	
8	33	SE.	2	"	Wood 48	12	65	-9	0	"	"	"	"	D.	---	
8	33	SE.	3	"	Conc.120	15	42	-12	0	"	"	"	"	D.	---	
8	33	SW.	4	"	" 36	14	35	-10	0	"	"	"	"	D.	---	
8	33	SW.	5	Drn.	Iron 2	16	40	-14	0	"	"	"	"	D.	---	
8	34	NE.	1	Dug	Conc.36	14	40	-10	8	Gravel	Colebrook	"	Dom., Stk.	D.G.N.	---	
8	34	SE.	2	"	" 36	9	79	-7	0	Sand	Sunnyside	"	Dom., Stk.	D.	---	
8	34	NW.	3	"	" 48	9	65	-4	0	"	"	"	Dom., Stk.	D.	---	
8	34	NW.	4	"	Wood 36	12	52	-5	0	"	"	"	Dom.	D.	---	
9	3	NE.	1	"	Conc.36	7	13	-5	0	Gravel	Alouette	"	Dom., Stk.	E.	10,000	Estimated yield.
9	3	SE.	2	"	" 30	10	48	-6	5	"	Colebrook	"	Dom.	F.N.	---	
9	3	SW.	3	"	" 36	12	47	-6	0	"	Alouette	"	"	E.	---	
9	3	SW.	4	"	" 36	10	41	-7	0	"	"	"	Dom., Stk.	E.	---	
9	3	SW.	5	"	Wood 48	8	25	-6	0	"	"	"	Dom., Ind.	E.	---	Surrey Cedar Co.
9	4	SE.	1	"	" 42	12	52	-11	0	Sand	Sunnyside	"	Dom., Stk.	D.	---	
9	4	SW.	2	"	" 48	11	50	-8	0	Sand,gravel	"	"	Dom., Stk.	D.E.F.	---	Gravel aquifer probably Alouette.
9	4	SE.	3	"	" 120	14	15	-13	0	" "	"	"	Dom., Ind.	E.F.	---	Pt. Kells Sawmill.
9	5	SE.	1	"	" 48	11	100	-7	0	Gravel	"	"	Dom.	E.	---	
9	5	SE.	2	Spr.	" 48	2	105	0	0	Sand	Quadra	"	"	Q.	200	
9	5	SW.	3	Dug	Conc.36	35	181	-31	---	"	"	"	"	G.I.Q.	---	
9	5	NW.	4	"	" 36	10	165	-9	5	"	"	"	"	G.I.Q.	---	
9	5	NW.	5	"	Wood 36	8	135	-5	---	---	---	"	"	---	---	Log incomplete.
9	5	NW.	6	"	" 36	5	100	-4	5	Sand	Quadra	"	"	C.Q.	---	Shells in Quadra sediments.
9	5	NE.	7	Spr.	" 48	4	115	0	0	"	"	"	"	Q.	---	
9	6	SE.	1	Dug	" 48	36	197	-33	7	"	"	"	Dom., Stk.	G.I.Q.	---	
9	6	SE.	2	"	Conc.36	57	210	-50	15	"	"	"	Dom., Stk.	G.I.Q.	---	
9	6	SW.	3	"	" 48	7	50	-4	7	Gravel	Colebrook	"	Dom., Stk.	G.I.N.	---	

LOCATION			WELL NO.	DESCRIPTION OF WELL					PRINCIPAL AQUIFERS			WATER		FORMATIONS PENETRATED	YIELD	REMARKS
Tp.	Sec.	¼		Type	Casing, diam. (inches)	Depth (ft.)	Collar Elev., (ft.)	Static Level (ft.)	Depth to top (ft.)	Character of material	Formation	Quality	Use		(gals /hr)	
9	6	SW.	4	Dug	Conc.48	14	90	-10	14	Gravel	Colebrook	Soft	Dom., Stk.	G.I.N.	---	
9	6	NW.	5	Drl.	Iron 5	60	209	-46	49	"	"	"	Dom.	G.I.N.	---	
9	6	NW.	6	Dug	Conc.60	20	189	-11	---	---	---	---	"	---	---	Log incomplete.
9	6	NW.	7	Drl.	Iron 4	60	135	-52	12	Gravel	Colebrook	Soft	"	G.I.N.	---	
Blk.	Rge.	Lot														
5N	1W	7	1	Drl.	Iron 4	130	245	-126	126	Sand	pre-Vashon	Soft	Dom.	C.G.I.J.	500	
5N	1W	7	2	Dug	Wood 72	12	82	-9	4	"	Quadra	"	Dom., Stk.	C.Q.	---	
5N	1W	10	1	Spr.	--- --	0	147	0	0	Gravel	---	"	Dom., Stk.	---	---	
5N	1W	14	4	Dug	--- 60	17	198	-16	11	"	Colebrook	"	Dom.	G.N.	---	
5N	1W	16	2	"	--- 54	34	288	-12	---	---	---	"	Dom., Stk.	---	---	Log incomplete.
5N	1W	20	1	"	--- 48	20	293	-12	19	Sand, gravel	Colebrook	"	Dom., Stk.	G.I.N.	---	
5N	1W	20	2	"	--- 48	25	282	-21	---	" "	"	"	Dom., Stk.	---	---	Log incomplete.
5N	1W	20	3	Spr.	--- --	0	255	0	0	" "	"	"	Dom., Stk.	N.	---	Also used for irrigation.
5N	1W	22	1	Dug	--- 36	12	220	-8	12	" "	"	"	Dom., Stk.	G.N.	---	
5N	1W	22	3	"	--- 72	65	268	-35	---	---	---	"	Dom.	---	---	Log incomplete.
5N	1W	24	1	"	Wood 60	32	138	-29	---	---	---	"	"	---	---	" "
5N	1W	24	2	"	" 48	23	198	-20	9	Sand	Quadra	"	"	G.Q.	---	
5N	1W	24	3	"	--- 60	32	195	-28	12	"	"	"	"	G.Q.	---	
5N	1W	25	1	"	Wood 36	23	195	-18	2	"	Quadra?	"	Dom., Stk.	G.N.Q.	---	
5N	1W	26	5	"	--- 48	12	184	-9	9	"	Colebrook	"	Dom., Stk.	G.I.N.	---	Log incomplete.
5N	1W	27	6	"	--- 60	16	255	-11	16	Sand, gravel	"	"	Dom.	G.I.N.	---	
5N	1W	28	4	"	--- 60	20	290	-10	20	" "	"	"	Dom., Stk.	G.I.N.	---	
5N	1W	28	5	"	--- 48	17	255	-14	17	" "	"	"	Dom.	G.I.N.	---	
5N	1W	32	1	"	--- 48	24	322	-16	---	" "	"	"	Dom., Stk.	G.I.N.	---	Log incomplete.
5N	1W	33	2	"	--- 48	9	300	-5	8	" "	"	"	Dom., Stk.	G.I.N.	---	
5N	1W	33	3	"	--- 48	25	292	-17	25	" "	"	"	Dom., Stk.	G.I.N.	---	
5N	1W	34	1	Drl.	Iron 5	38	230	-30	38	Sand	Quadra	"	Pub.	G.I.N.Q.	---	North Surrey High School.
5N	1W	35	1	Spr.	--- 48	4	91	0	0	"	---	"	Dom.	---	---	
5N	1W	35	2	Dug	--- 36	18	173	-14	---	---	---	"	"	---	---	Log incomplete.
5N	1W	36	1	"	Wood 48	17	100	-12	---	---	---	"	"	---	---	" "
5N	2W	36	1	"	Conc.72	60	270	-59	34	Sand, gravel	Semiamu	"	"	G.I.K.L.	2000	Channel gravel.