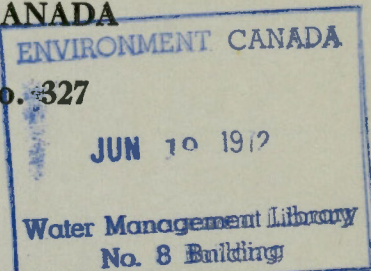


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TECHNICAL SURVEYS

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GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 327



GROUND-WATER RESOURCES  
OF  
LANGLEY MUNICIPALITY  
BRITISH COLUMBIA

By

E. C. Halstead



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OTTAWA  
1957

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GROUND-WATER RESOURCES  
of  
LANGLEY MUNICIPALITY, BRITISH COLUMBIA

CHAPTER I

INTRODUCTION

This report deals with ground-water conditions of Langley municipality in the province of British Columbia investigated by the Geological Survey of Canada during the field seasons of 1954 and 1955. Geological mapping of the area was carried out under the direction of J.E. Armstrong, who has supplied Chapter II of this report. The writer supervised the ground-water investigation and collected much of the water data. Others whose assistance in the field is acknowledged were: in 1954, G. Rayner; in 1955, J. Stothers and P. Strack. The writer wishes to thank all well owners and drillers for their cooperation 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 gravel and sand aquifers deposited as outwash plains at or near the surface will yield large supplies of free ground water. Confined artesian water is available in aquifers of sand and gravel within 300 feet of the land surface in the upland areas, whereas, flowing artesian water is available in the Langley Lowland where wells are drilled from 50 to more than 900 feet.

METHODS OF INVESTIGATION

The investigation included the collection of data on more than 1,000 wells in the area. These records vary greatly in accuracy as in most cases no drilling data were recorded and the information obtained was 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 showed that, on the basis of known geology, the information obtained on about 250 wells could be interpreted with accuracy, and only these data 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

Langley municipality lies within the Fraser Lowland and extends from the Canada-United States boundary (700 feet north of the 49th Parallel) for a maximum of 13 miles, to latitude  $49^{\circ}13'N$ . The eastern boundary follows a meridian a few seconds east of  $122^{\circ}28'W$  and the western boundary of the municipality follows a meridian a few seconds east of  $122^{\circ}41'W$ . The area of the municipality is about 122 square miles.

#### CLIMATE

The mountains north and east of Fraser Lowland are the most important factor that influences the climate of this area. Annual precipitation at the foot of the Pacific Ranges is 80 inches whereas on the Fraser Delta it averages 35 inches. Heavy winter rainfall and a summer dry period are characteristic. About 70 per cent of the precipitation occurs during the period October to March. Even in the wet years the growing season, from April to September, has too little precipitation for the maximum development and yield of crops.

Within Fraser Lowland summer rainfall is highly variable and unpredictable. July is the driest month and generally drought conditions prevail one year out of every five or six. During drought conditions experienced in 1951 and 1952, crop production in Langley municipality was markedly affected. This led to an increased interest in irrigation, and particularly in the use of ground water for this purpose.

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 low. These considerations show that apart from run-off, which is appreciable in the upland 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<sup>1</sup>

The type of agriculture throughout the Fraser Lowland 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 Lowland's produce, also determine to some extent what is grown.

The black soils attracted much attention and farming began shortly after Fort Langley was established as a trading post in 1827. Dairying, mixed farming, market gardening and the growing of small fruits are the main types of agriculture. Small fruit production, centred in Fraser Lowland, amounts to 85 per cent of the total provincial fruit production. The raising of chickens and turkeys is carried on extensively in the upland areas.

In Langley Lowland dairying has been the main type of agriculture. An ample supply of flowing artesian water is available. By 1914 some 270 flowing wells had been drilled in the Surrey and Langley districts. A total of 450,492 gallons a day was estimated as being discharged from 101 of these wells whereas the total requirements of the 74 interests dependent on this water amounted to approximately 50,000 gallons a day<sup>2</sup>.

### POPULATION

According to a census taken in 1955, the population of Langley municipality is 11,194 and that of Langley city is 2,022.

### TOPOGRAPHY AND DRAINAGE

Langley municipality forms a part of Fraser Lowland of southwestern

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<sup>1</sup>

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

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<sup>2</sup>

Province of British Columbia, Report of Water Rights Branch of the Department of Lands, for the year ending December 31st, 1914, p. 19.

British Columbia, which in turn forms a part of the Georgia Depression. Fraser River, along the north boundary of the municipality, occupies a post-glacial valley up to 3 miles wide and 50 feet or more deep. This 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 that is 19 miles long and 15 miles wide and still growing.

Langley Lowland, a former embayment of the sea, separates the two major upland areas of the municipality. The floor of this lowland is relatively flat and is drained south from Milner by Nicomekl River and north from Jardine Station by Salmon River. The elevation of the lowland in its broad centre part is about 25 feet above sea-level but arches slightly to attain elevations of more than 50 feet between Milner and Jardine Station. North of Jardine Station the lowland narrows, has considerably more relief and joins a former meander channel of Fraser River that presents a flat semi-circular area about 1 mile wide surrounding an upland of about one square mile, on which Fort Langley is built.

Clayton Upland in the northeast quarter of the municipality trends northeast and is bordered on the south and east by Langley Lowland and on the north and west by a lowland area extending to Fraser River. Clayton Upland is a rolling hilly surface 200 to 300 feet above sea-level. This upland is nearly ellipsoidal in shape and lies partly in Surrey Municipality. Run-off from this upland collects in rivulets and short streams that cut deep narrow channels into the surface and drain north to Fraser River. The slopes bordering Langley Lowland are abrupt and have been modified by wave-cutting and later slope wash.

Langley Upland occupies the east and south part of the municipality. It is bounded on the north by Glen Valley and Fraser River, on the north and west by Langley Lowland and on the southwest by Campbell Upland. The surface is hilly and in places reaches elevations of more than 400 feet above sea-level. Run-off over this hilly surface is drained to the south by Bertrand Creek, to the west by Campbell River and along Langley Lowland by tributaries of Nicomekl and Salmon Rivers. An area of about



4 square miles north of Trans-Canada Highway and bounded by Livingstone and Otter roads has a flat surface which drops off abruptly on the west side and is cut by a tributary of Salmon River.

Campbell Upland, an area of about 11 square miles, is partly in Surrey municipality. It has a flat-topped terraced surface 125 to 150 feet above sea-level. Campbell Creek crosses the north part of this upland.

Glen Valley in the northeast corner of the municipality has a flat floor 20 feet above sea-level from which slopes rise abruptly to elevations of more than 350 feet. Part of Glen Valley is in Matsqui municipality. This valley represents a meander channel of an earlier stage of Fraser River that has been cut off by lowering of the present channel or an embayment cut by water of Stave River at its entrance with the Fraser. Short creeks originating in the upland areas south and east of Glen Valley have cut narrow valleys through the steep slopes and spill out in natural or man-made drainage channels across the floor of the valley.

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- Proceedings of the first irrigation conference, Lower Mainland of British Columbia, March 21, 1952.
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## CHAPTER II

### PLEISTOCENE AND RECENT GEOLOGY <sup>1</sup>

#### TYPES OF DEPOSITS

The entire municipality of Langley is underlain by thick deposits of unconsolidated sediments of Pleistocene and Recent ages. The term Pleistocene refers to that epoch in the earth's geological history when large areas of the earth's surface were periodically covered by great glaciers many thousands of feet thick. The epoch is estimated to have started about one million years ago and to have continued in the Langley area to within five to eight thousand years of the present. The term Recent has been used to refer to post-glacial time.

The deposits formed during the Pleistocene and Recent periods are shown on the table of surficial deposits accompanying this report. They consist of clay, silt, sand, gravel, peat, varved clay and silt; stony, clayey silt, silty clay and related till-like mixtures; and till. The terms clay, silt, and sand as used in this report are based on the diameter of the constituent particles and are used as follows: clay, less than 0.002 mm.; silt, 0.002 to 0.05 mm.; and sand, 0.05 to 2 mm.

The clays and silts are composed chiefly of rock flour produced by mechanical abrasion by glaciers and only to a very minor extent of clay minerals formed by chemical decomposition of rocks. The sands are in a large part quartz but contain in addition many feldspar and rock fragments. The clays and silts and mixtures of the two are mainly off-shore marine deposits, and to a much lesser extent stream and river deposits, both flood plain and channel. The sands and also the gravels may be outwash, (glacio-fluvial) beach, or stream and river deposits. Outwash consists of the sediments deposited by streams issuing from glaciers. The peat represents swamp deposits. Varved clay and silt are glacial-lake deposits consisting of alternating light and dark coloured layers a fraction of an inch to several inches thick.

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<sup>1</sup> Chapter written by J.E. Armstrong

The stony, clayey silt, silty clay, and related till-like mixtures are in a large part glacio-marine and to a lesser extent normal marine deposits that were laid down in the sea during the advance and retreat of an ice-sheet and during the subsequent uplift of the land. The glacio-marine deposits are marine drift; that is, the stones and part of the fine material were transported by floating ice and the remainder of the fine material was carried by meltwater and sea water. The somewhat similar deposits of normal marine origin are mainly reworked till and reworked marine drift resulting from submarine erosion as the land rose above the sea. Mechanical analyses of stony, clayey silts and silty clays, show that, exclusive of stones, they comprise about 40 per cent silt, 40 per cent sand, and 20 per cent clay.

Glacial till, as used in this report, is a very compact unsorted mixture of sand, silt, clay, and stones deposited directly beneath glacial ice. The only tills exposed in Langley municipality are the Sumas and Surrey, of the older tills only Semiamu has been identified in well records. Mechanical analyses of the fine fraction of representative samples of tills from the 'Lower Mainland' yielded the following average results: Sumas till, 63 per cent sand, 33 per cent silt, and 4 per cent clay; Surrey till, 57 per cent sand, 41 per cent silt, and 2 per cent clay; and Semiamu till, 47 per cent sand, 45 per cent silt, and 8 per cent clay.

The unconsolidated sediments in Langley municipality attain a maximum thickness of at least 1,000 feet and in places may be much thicker; for example, the Cloverdale sediments alone are more than 900 feet thick in the Milner area.

#### STRATIGRAPHY AND HISTORICAL GEOLOGY OF PLEISTOCENE AND RECENT DEPOSITS

The table of surficial deposits that accompanies this report shows graphically the complex interrelations and age of the surficial materials. The oldest deposits are shown at the bottom of the table and the youngest at the top. Deposits shown along side one another indicate that they are of the same general age but were laid down in different environments. Note that the graphic representation illustrates, for example, that Sumas glacial

deposits were laid down in part of the area at the same time non-glacial Capilano deposits were laid down elsewhere in the area. A hole drilled in search of water 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.

All ages are relative except in the case of the Capilano and Quadra deposits, where radio-carbon age determinations have been made on wood collected from them outside the map-area. Wood from the base of Sumas till, and hence a part of the Capilano group, was dated as  $11,300 \pm 300$  years old. Wood from the Quadra group inter-till sediments was dated as older than 30,000 years.

Study of the table of surficial deposits indicates that the area was subjected to four glaciations: three probably major, namely, Seymour, Semiamu, and Vashon; and one, Sumas, probably valley glaciation only. The Seymour and Vashon glaciations reached ice-sheet proportions during their maxima at which time they were probably 7,500 feet or more thick over the valleys. At these times the ice moved in a general southerly direction; that is, off the Coast Mountains. The Semiamu ice was probably also of ice-sheet proportion, but due to later erosion, deposits of this group are so poorly preserved that a reliable history of this ice advance cannot be pieced together. Post-Vashon Sumas valley ice advanced into the northeastern part of Langley municipality and recessional Abbotsford outwash related to this ice advanced westward across the municipality.

During each major glaciation the land was depressed relative to the sea, and this lowering of the land surface amounted to at least 1,000 feet in the case of Vashon glaciation. At the maximum of Vashon glaciation the ice rested on the sea floor. Maryhill outwash was deposited in advance of the ice and Surrey till beneath the ice. During the retreat of Vashon ice, largely by wasting, the ice thinned and floated and glacio-marine Newton stony clay deposits were laid down. After the Vashon ice melted and as the land rose above the sea, the off-shore marine Cloverdale sediments and the marine-shore Sunnyside sand and Bose gravel deposits were

laid down.

During post-Vashon time the Sumas valley ice advanced westward into Langley municipality. In its initial advance stages this ice-sheet terminated in the sea and deposited glacio-marine Whatcom deposits in front of and beneath the ice. At the same time normal marine deposits were laid down in the sea west of the Sumas ice-sheet. As the land rose the Sumas glacier was grounded and advanced and retreated across the Whatcom glacio-marine drift depositing Sumas till and recessional Abottsford outwash.

Up to the end of 1955 a total of about 45 species of marine fossil shells had been collected and identified from Newton stony clay. Whatcom glacio-marine, Cloverdale sediments, Sunnyside sand, and Bose gravel deposits. They were collected from more than 50 localities within the Fraser Lowland ranging from 5 to 575 feet above sea-level. Marine shells similar to these assemblages are now found in the sea in latitudes ranging from 60° to 63° North; that is, 760 to 950 miles north of Langley.

As shown in the table of surficial deposits, one probable interglacial period, the Quadra, has been recognized between the Seymour and Semiamu ice-sheets. Apparently climatic conditions existing at that time were somewhat similar to those at present as is indicated by a study of the pollen and plants from the peat of the Point Grey beds.

Huntingdon gravel deposits underlie Whatcom glacio-marine deposits. They appear to be stream deposits that were laid down following the retreat of Vashon ice but before the advance of Sumas ice. West of Langley municipality the deposition of similar gravel probably continued throughout Capilano time.

Two major erosion intervals are shown on the table of surficial deposits, one separating the Semiamu from the Quadra group below and the other separating the Semiamu from the Vashon group above. The hills in the Fraser Lowland were shaped during the latter erosion interval and were mantled by Vashon group deposits. Surrey till conforms to the slopes of the hills truncating underlying older deposits.

The Salish deposits, which are still in the process of formation,



consist of channel and flood plain deposits of the Fraser River and smaller streams, and peat bogs.

#### DISTRIBUTION OF PLEISTOCENE AND RECENT DEPOSITS

The distribution of the Sumas and younger deposits is fairly obvious from a study of the geological map accompanying this paper. The Salish and the non-glacial Capilano deposits, except for Bose gravel and Sunnyside sand, are confined to the lowlands.

Pre-Seymour and Seymour deposits are not exposed in the area, but several wildcat holes drilled in a search for oil and gas and a few of the deeper drilled water wells intersect unconsolidated and semi-consolidated sediments believed to be correlative to Seymour and older.

Quadra sediments, mainly Nicomekl silt deposits, are exposed on the lower slopes of Clayton Upland. Many of the drilled wells in this upland intersect similar sediments. Semiamu deposits are not exposed in the municipality but have been positively identified in the deep well drilled by the Royal Canadian Navy near Aldergrove, and have been tentatively identified in other holes.

Exposures of Surrey till are found only in the western part of the municipality, however this till is widespread beneath Newton and Whatcom glacio-marine deposits throughout Langley. Newton stony clay deposits appear at the surface in most of Clayton Upland, elsewhere they underlie lithologically similar Whatcom deposits and, except where separated by Huntingdon gravel, the contact between the two is in many places arbitrarily drawn. Also the surface mapping of the Newton and Whatcom has been done partly on a geographic basis; west of the Langley-Milner valley has been shown as Newton and east as Whatcom; whereas locally evidence may be lacking to support this mapping.

Huntingdon gravel deposits outcrop only in a few scattered areas, but are widespread beneath Whatcom deposits.

### CHAPTER III

#### GROUND-WATER GEOLOGY

##### GENERAL CONDITIONS

Ground water or underground water is the water that supplies springs and wells. Where surface water is lacking, contaminated or not in sufficient supply, man has dug wells in search of ground-water supplies. The presence and development of ground water, especially in arid or semi-arid regions, have determined the growth or absence of civilization.

The water stored in ground-water reservoirs is replenished during wet seasons and hence is a renewable resource. In many places ground water in sufficient quantity can be found to meet the demands of agriculture and industry without constructing large, long pipelines or aqueducts to carry water into an area from distant surface sources. The amount of water replenished annually and the amount available in storage in the ground-water reservoirs are important factors to be considered before undertaking programs of ground-water development.

##### Source

The source of all ground water is the precipitation that falls on the immediate or adjacent area, but only part of the water falling on an area will penetrate to the ground-water reservoirs. Part flows off the surface and part is held in the soil to be used by the plants and vegetation. An accurate estimate of the amount of rainfall that penetrates to the underground storage in Langley municipality, is considered beyond the scope of this report. However, an inch of rainfall on 1 square mile is equivalent to approximately 14,520,000 imperial gallons and in Langley municipality the average rainfall is 40 inches a year. If, say, 15 per cent of this rainfall is contributed to ground-water storage then 87,120,000 gallons<sup>1</sup> per square mile would be available annually for ground-water recharge.

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<sup>1</sup>

"Gallons" in this report refers to "imperial gallons".

### Occurrence

Pores and open spaces in both consolidated and unconsolidated rocks provide the openings through which ground water moves. Therefore, the size, shape and relation of these openings to one another control the quantity of water that the rock can hold and also the ease or ability with which the rock gives up the water. If the openings or pore spaces are large and interconnected, as they commonly are in sand and gravel, the water is transmitted freely and the rock is said to be permeable. Where the pore spaces are very small, as in clay, the water is transmitted very slowly or not at all and the rock is said to be impermeable. Furthermore, a deposit of uniformly sized, well rounded material may be more porous and permeable than a variously sized material because in the latter the smaller particles occupy the interstices between the larger ones.

In rocks that are saturated all the pore spaces are filled with water. This condition exists in clay as well as in sand and gravel, but the pore spaces in sand and gravel are larger and hence the rock is more permeable, therefore successful wells are more likely to be developed in the coarser materials. The difference in permeability between two rocks, such as sand and clay, allows for seeps and springs. Water percolating through porous sand upon encountering a layer of clay cannot move as readily through it because the pore spaces are minute. The water moves along the top of the clay layer and issues as springs or seeps where the top of the clay layer is exposed along hillsides or road-cuts.

### Water-Table and Movement of Ground Water

Rain falling on an area of sand and gravel percolates downward through the pore spaces between the grains composing the sand and gravel. The downward percolation by the force of gravity continues until a zone is reached in which all the pore spaces are filled. This zone is the zone of saturation and its upper surface is the water-table. In Langley municipality this condition exists in two areas, one the Campbell Upland and the other an area of Abbotsford outwash in the central part of Langley Upland. Both areas constitute a free ground-water reservoir.

Elsewhere the ground water is confined below relatively impervious layers such as glacial till and glacio-marine clays. The water in such aquifers known as confined ground-water reservoirs is under pressure such that when the strata are penetrated by a well, water rises in the casing. The surface to which the confined water rises is the pressure or piezometric surface. In the lowland areas the water is commonly under sufficient pressure to rise to a point above the ground surface and flow, whereas in other areas the pressure is sufficient only to raise the water to a point above the aquifer.

It is evident then that no continuous over-all free water-table exists under Langley municipality. A continuous water-table exists in areas of free ground water but elsewhere the ground water rises to a pressure surface that does not coincide with the free ground-water tables.

Water penetrating the soil zones or entering from streams penetrates downward to a saturated zone where there is lateral movement from areas of recharge to lower areas of natural discharge. The rate of movement may be in the order of only a few inches a year in the marine clays and a foot or more a day in uniform sands.

Fluctuations of the water-table are in response to the amount of water that is either added to or subtracted from the ground-water reservoir. In Langley municipality lowering of the water-table is due to subsurface drainage to adjoining areas or to overdraft by excessive pumping. The water-table is raised by additions to the reservoir either from rainfall or seepage water from adjacent areas. If a well does not penetrate the lowest level of the water-table it can be expected to go dry.

The pressure surface is lowered in the lowland areas by too many wells flowing freely. This is evident where wells have been drilled nearby a former flowing well and, after drilling, the original well ceases to flow.

#### Recharge

Water that penetrates to the saturated zone and is added to the

ground-water reservoirs is recharge. Recharge is dependent upon precipitation and its distribution throughout the year. Rain falling in the growing season will contribute little or nothing to the recharging of an aquifer as the water is lost in evaporation, run-off, or used by plants. The precipitation as rain or snow during periods of dormant growth provides the maximum recharge. Rising water-tables can be expected during February and March as a result of heavy rainfall during the months of October and November. However, where the rate of downward penetration and lateral movement of the recharge water is reduced by material of low permeability no rise in the water-table or static level in a well may be noticeable until the summer months.

Aquifers in Langley municipality are also recharged by infiltration from aquifers in the highlands east of the municipality. It is also suggested that the Langley Lowland receives recharge from waters of Fraser River that infiltrates through gravel and sand along the bed of the river.

#### Discharge

Ground water is discharged by springs, subsurface flow, evaporation and transpiration. Ground water is discharged by springs in Langley municipality along the boundaries of outwash areas and at the edge of the uplands. Discharge by underground outflow is probably balanced by that quantity flowing in by underground replenishment. The loss of ground water by evaporation from the surface soil and the loss through the transpiration of plants where the water-table is near the surface is probably a minor amount under the climatic conditions characteristic of the Fraser Lowland.

Artificial discharge takes place through wells and considerable ground water is wasted in the Langley Lowland where at least 200 artesian wells discharge on the average 500 gallons an hour each or 2,400,000 gallons a day. The rate of flow of these wells could be lessened by installing higher standpipes on the wells thus reducing the overflow; however, this procedure also reduces the pressure at the outlet. The installation of valves on these wells would reduce the flow but there is also risk of



someone closing the valve and upon reopening, pressure built up is released and fine sands are pulled into the well plugging the casing.

### GROUND-WATER RESERVOIRS

Two main types of ground-water reservoirs are present in Langley municipality, namely, free ground-water reservoirs and confined ground-water reservoirs. Both types may be perched in that they are separated from the main body of ground water by nearly impervious sediments such as clay, stony clay or till. In this report the term ground-water reservoir is used interchangeably with the term aquifer. An aquifer includes not only individual water-bearing beds a few feet thick but also a thick series of beds of varying permeability where the individual beds are more or less interconnected hydraulically.

#### Free Ground-Water Reservoirs

The glacio-fluvial deposits mapped as Abbotsford outwash (9)<sup>1</sup> which cover 10,000 acres or more, range in depth from 5 to more than 100 feet and constitute areas of free ground-water reservoirs. Water falling on the surface of such an area penetrates downward by gravity and occupies the interstices between the grains of sand and gravel. The water is not confined but moves under the influence of water-table slopes. If the sand and gravel are underlain by impervious or nearly impervious sediments the free ground-water reservoir is perched. The static level of the water in wells penetrating free ground-water reservoirs whether perched or not is the water-table and such wells are non-artesian water-table wells.

Newton (3) and Whatcom (7) glacio-marine stony clayey silts and silty clay that mantle the upland areas are nearly impervious but capable of passing small quantities of water, especially where they contain small lenses of coarser material. These glacio-marine deposits constitute a perched free ground-water reservoir of limited storage capacity and shallow wells dug in them will yield a limited supply of water commonly

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Numbers in brackets are those of map-units on the accompanying geological maps.

not sufficient for domestic use. These wells act as natural cisterns that fill during the rainy season and if placed to take advantage of local slopes, catch natural drainage during dry periods.

#### Confined Ground-Water Reservoirs

The water in confined ground-water reservoirs does not move under the influence of water-table slopes but is confined by an overlying impervious stratum and, hence, movement is restricted vertically but not necessarily horizontally. The Cloverdale sediments (4) of the Langley Lowland are in places as much as 900 feet thick and consist of lenses of coarser units within the clay and silt. These lenses represent confined ground-water reservoirs that may be interconnected or separate and the water that they contain is under pressure and rises to the surface to flow where such lenses are penetrated by wells.

In the upland areas ground-water reservoirs of Huntingdon gravel (5) and pre-Vashon deposits (1) are confined below the nearly impervious Whatcom (7) and Newton (3) deposits and Surrey till (2). The water in these reservoirs is under pressure sufficient to raise it above the top of the confined reservoir but not sufficient to raise it to the land surface to flow as a flowing artesian well. The recharge area to the confined reservoirs may not be adequate and the initial yield may give an erroneous impression that an abundant perennial supply is available. However, in most places the sand and gravel between the stony clays are thick enough to constitute confined ground-water reservoirs capable of supplying water in the order of 5 to 20 gallons a minute.

## CHAPTER IV

### TYPES OF WELLS AND WELL DEVELOPMENT

The trend in modern well drilling is towards the development of wells. Therefore, this section is added to draw the attention of engineers, drillers, and prospective well owners in Langley municipality to certain fundamental principles of ground-water recovery and well use so that they may know the problems that exist and corrective measures that are being employed elsewhere. Additional information may be obtained from drillers' magazines and from some of the references listed on page 5 of this report.

A well is constructed to tap the ground-water reservoirs and obtain therefrom, as economically as possible, the required amount of ground water. Failure to obtain water is due either to conditions existing in the formations penetrated or to the type of well and construction methods used.

### TYPES OF WELLS

Dug, bored, driven and drilled wells are the four main types and each has its special use and function under existing conditions. The factors that determine the type of well 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 investment that the prospective owner wishes to make.

Dug wells are of limited usefulness in Langley municipality because the depth to an abundant water supply normally exceeds 30 feet and over a large part of the municipality the ground water is under hydrostatic pressure beneath a confining impervious bed. Dug wells in the upland areas penetrate Newton (3) or Whatcom (7) stony clays, are easy to dig, but their yield fluctuates seasonally. Most of the water is collected from surface run-off and therefore these wells act chiefly as cisterns. Dug wells are effective on the lower slopes of the uplands near the spring line and in areas of extensive outwash.

Bored wells, sunk by means of a hand or power driven auger, are not widely used but where the stony clays are 50 feet or less thick

power driven bucket type augers could be used to penetrate to the underlying water-bearing sands. Bored wells that reach running sands or quicksand may yield enough water if sandpoints are driven into the bottom of them.

Driven wells are constructed by driving a casing tipped with a drive point or sandpoint. Although an advantage over a dug well, driven wells are limited in their use to areas of outwash where the sands are medium to coarse grained. Driving sandpoints through the marine clays on uplands to underlying sands is not recommended as stones are encountered in the clays. In Langley Lowland the Cloverdale sediments (4) are too fine to give up water contained in them to pumps attached to sandpoints, however sandpoints can be used in areas of Sunnyside sand (6).

Drilled wells are the most effective for development of ground water in a large part of Langley municipality. They may be finished as open-end, screened or gravel-packed wells, all of which are lined with a casing commonly 6 inches in diameter. Cable tool drilling rigs are used to drill such wells but in Langley Lowland where the water is present under pressure sufficient to cause it to rise to the surface and flow, wells are drilled by means of a jetting rig. In jetting a well, the casing less than 2 inches in diameter is forced down during the drilling as the sands and sediments are washed up by means of water forced through the drill stem. These wells are common in the lowland areas and penetrate depths of as much as 700 feet.

An open-end well allows water to enter through the open end of the casing. No screen or other device is used to keep sand from entering the well and hence failures are common especially when over-pumping is carried on. All wells drilled by the jetting method are open-end wells.

Screened wells are those in which some sort of a device such as a screen or strainer is used on the lower end of the casing to prevent the infiltration of fine sand into the well under pumping. Depending on the method of development used after installation of the screen or strainer, the well becomes either naturally gravel packed or gravel is added as a packing around the screen. By use of proper developing equipment, the

the fine material around the screen is removed through the screen. This development grades the material in the water-bearing formation in such a way that the greatest possible amount of open space is provided for the water to flow through. Where the water-bearing material is so fine and uniform in size that natural gravel packing is impossible, gravel may be introduced around the screen as a packing. Such wells are gravel treated wells, and where this treatment is anticipated the initial well is drilled with a larger diameter than the final well so that the gravel can be packed around the screen after the screen has been placed in position.

#### WELL DEVELOPMENT

Wells are developed by means of post-drilling treatments to establish the maximum rate of usable water yield. To improve the yield, the methods commonly used include surging, over-pumping, backwashing and treatment with acids, or other chemicals. All methods, except the acid treatment, are designed primarily to wash the fine sand, silt or clay from the water-bearing formation immediately surrounding the well screen.

Surging is the method most commonly used where the water-bearing materials contain sand and fine gravel mixed with silt but over-pumping is a satisfactory procedure where coarse sand and gravel make up the aquifer. The surging method involves the use of a surge plunger which is operated up and down in the well casing for the purpose of alternately creating an inward and outward movement of water through the screen. The repeated surging action eventually moves the fine sand up to and through the screen from where it is removed by bailing. After the fine particles have been drawn into the well and removed, the coarser particles left on the outside of the screen have created a new mixture of particles having a high porosity and permeability. The treatment known as backwashing includes operating the pump at its maximum capacity and periodically stopping the pumping and releasing the foot-check valve. The water then rushes back into the well and agitates the sediment around the screen.



A developed well provides the greatest possible amount of water from the water-bearing material into which the well is drilled. Therefore, wells are developed to increase their specific capacity or yield per foot of drawdown. During pumping the water in the well drops from its static level to the pumping level, and this drop measured in feet is known as the drawdown. As the water in the well drops to the pumping level, the attitude of the water level in the aquifer around the well becomes that of an inverted cone. The size and shape of this cone, known as the cone of depression is controlled by 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 material 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.

The specific capacity or yield per foot of drawdown of a well should be determined especially when large flows are demanded. With the advent of the practice of irrigation to produce maximum crop yield it is necessary that wells drilled for this purpose be developed to maximum capacity as they will be subjected to long term pumping. Most wells drilled for domestic or farm needs do not require extensive development as the initial yield meets the water requirements.

## CHAPTER V

### GROUND-WATER GEOLOGY OF LANGLEY MUNICIPALITY

Ground water is obtained in Langley municipality from free or confined ground-water reservoirs. Free ground-water reservoirs, as shown on the accompanying map, are those areas where Abbotsford outwash (9) and Sunnyside sand (6) are at or near the surface. Wells that tap free ground-water reservoirs are non-artesian. Confined ground-water reservoirs supply water that is under pressure such that when the reservoir is penetrated by the drill the water rises in the well casing and in some cases flows at the surface. Huntingdon gravel (5), Cloverdale sediments (4) and pre-Vashon deposits of sand and gravel (1) are the principal confined ground-water reservoirs.

#### CAMPBELL UPLAND

Campbell Upland has an area of 10 square miles of which 7 square miles are in Langley municipality. It is underlain by Abbotsford outwash (9) which consists of permeable sand and gravel that constitutes the ground-water reservoir. The water-table conforms closely to the topography of the terraced upland and slopes about 25 feet to a mile but adjacent to Anderson Creek the slope steepens to 200 feet to the mile. The water-table may drop as much as 3 feet during periods of less than normal rainfall, such as that experienced during the summer of 1951, and will remain at this level until early winter.

The total thickness of the outwash on this upland is not known. In SW.  $\frac{1}{4}$  sec. 27, tp. 7, on the border of Langley and Surrey municipalities, a test hole penetrated 88 feet of outwash sand and gravel. The water level in this test hole remains at 16 feet below the surface of the ground but drops to as much as 19 feet during dry summer months. The well was test pumped at about 200 gallons per minute.

#### Ground-Water Recharge and Discharge

Campbell Upland is ideally suited for an infiltration area. The coarseness of the outwash and the flat topography of this upland 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  $3\frac{1}{2}$  billion gallons will recharge this reservoir annually. Anderson and Campbell Creeks continue to flow during drought seasons and are fed by ground water.

#### Recovery of Ground Water

Non-artesian wells up to 50 feet deep are used to recover the ground water, and sandpoints have also been used. The level of the water in these wells is the water-table. Upon consideration of the permeability of the outwash gravel and the annual recharge to this upland, it is reasonable to expect that drilled wells could be developed to deliver in the order of 500 gallons a minute.

#### CLAYTON UPLAND

The principal ground-water reservoirs underlying this upland are confined and included in the pre-Vashon group of sands and gravels (1). Perched ground water is present in the Newton stony clay (3) that covers the upland. Newton stony clay is 50 to 225 feet thick and in its upper limits yields a limited amount of water to cistern-type wells dug into it. Seasonal fluctuations of the water-table in these wells is such that during the summer months the wells are commonly dry. Two wells, drilled in the central part of the upland to depths of 222 feet and 256 feet, have encountered sands and gravels underlying the Newton stony clay. These gravels and sand, perhaps Semiamu sediments, are water bearing and are known to yield as much as 80 gallons a minute to open-end wells.

The main aquifers of this upland underlie the Newton stony clay (3) and, where present, Surrey till (2). From information available the piezometric surface closely parallels the topographic surface and also suggests a connection existing within the main aquifer. Along the slopes of the upland and below elevations of 150 feet the surface of the water-table drops steeply, between 300 and 500 feet a mile, whereas on the upland the water-table, as defined by the static level in non-flowing artesian wells, slopes 25 to 30 feet a mile.

#### Ground-water Recharge and Discharge

The total infiltration surface for the whole area of the upland is in the order of 5 square miles. The average annual rainfall is 40 inches of which perhaps 10 per cent penetrates the stony marine clays to recharge the underlying sands and gravels. Water is held from direct run-off on the surface by beach deposits of Sunnyside sand (6) overlying the marine stony clays.

Natural discharge is in part by springs and it is believed that these upland areas also discharge water from their main aquifers to the artesian aquifers underlying surrounding lowlands.

#### Recovery of Ground Water

Ground water is recovered by numerous dug wells and a limited number of deeper drilled wells. The dug wells rarely penetrate Newton stony clay (3) and are unsatisfactory in that the ground water supply is either lacking or dangerously low during the summer months.

The records of the following wells indicate that large quantities of ground water are available from aquifers underlying the marine stony clays and Surrey till (2). A well in SW.  $\frac{1}{4}$  sec. 22, tp. 8 penetrated 100 feet of marine clay and continued through 122 feet of pre-Vashon sand (1) and thin layers of silt and clay. Coarser sand and gravel was encountered at 222 feet and water in these gravels rose 64 feet in the casing. The well was test pumped for 9 days at 80 gallons a minute and the drawdown during pumping did not exceed 10 feet. In NE.  $\frac{1}{4}$  sec. 22, tp. 8 a well penetrated 80 feet of relatively impervious clay and continued 100 feet through pre-Vashon sand and silt. At 180 feet an aquifer was encountered in which non-flowing artesian water rose 80 feet in the casing. This supply has been sufficient for the stock and domestic needs of the farm but no record of a pumping test is available. At Willoughby school, NE.  $\frac{1}{4}$  sec. 23, tp. 8, an 8-inch diameter drilled well penetrated 225 feet of stony clay and 32 feet of sand that graded from fine to coarse at depth. The coarser sands are water bearing and the water rose 80 feet in the casing.

Other drilled wells have not been successful and their failure was due to either not being drilled deep enough, that is drilling operations were ceased before penetrating the stony clay, or to encountering fine sands that presented a problem in the well development which could not be solved by the drillers employed.

#### LANGLEY UPLAND

One free and at least two confined ground-water reservoirs exist within the Langley Upland. Free ground water is present in an area of about 10 square miles lying in the central part of Langley Upland north of Trans-Canada Highway. This is an area of Abbotsford outwash (9) that averages 5 to 10 feet in thickness along its eastern edge and thickens to as much as 80 feet along the western edge adjacent to Salmon River. The water-table slopes at a rate of about 60 feet to a mile but steepens to 200 feet to a mile adjacent to Salmon River. The permeability of the sands and gravels would allow at least 60 per cent of the rainfall to penetrate to the water-table and therefore the recharge is in the order of that estimated for Campbell Upland. Free ground water is recovered in the southeast corner of Langley Upland where local deposits of sand and gravel are exposed to the surface and provide infiltration for surface run-off. Elsewhere the aquifers are confined but interconnected as indicated by the static water levels in wells drilled to these aquifers.

Pre-Vashon sands and gravels (1) and Huntingdon gravel (5) are included in the main confined aquifers of this upland. Confined aquifers in pre-Vashon sand and gravel on the west side of the upland yield sufficient water for domestic and stock uses. Huntingdon gravel underlying 50 feet or more of Whatcom stony clay (5) supplies water in sufficient quantity to the users of the Aldergrove community wells. Huntingdon gravel underlying Whatcom stony clay is an important aquifer in an area near Roberts and Coghlan roads. The presence of ground-water bodies at depth is known only from the log of one drilled well at the Naval Station north of Aldergrove. In this well 19 feet of water-bearing sands were encountered below 46 feet of Whatcom stony clay. The water-bearing sands were underlain by 186 feet of Newton stony clay (3) and 78 feet of Surrey till (2). Water in sufficient supply was encountered in loose sand and gravel at a depth of 329 to 336 feet.

Sumas till (8) is present in the east part of the upland as a thin mantle covering hills of low elevation. This till is thin and porous and in places may constitute a free ground-water body. Sumas till, although not an important aquifer, does provide a storage zone for water near the surface and a spring line is present along its thin edges.

#### Ground-Water Recharge and Discharge

Whatcom stony clay that mantles most of the upland is relatively impervious but sufficient water penetrates it to supply recharge to the Huntingdon gravels. Sumas till where present retards surface run-off and temporarily stores ground water in perched ground-water reservoirs. Abbotsford outwash is porous and provides an excellent infiltration area for rainfall which can penetrate to ground-water storage.

Natural discharge is by means of springs. Those areas capped by Sumas till commonly have a spring line along their lower limits where the till thins. Ground water also discharges in springs along the borders of the Abbotsford outwash in the central part of the upland. One spring from this outwash flows at the rate of 180 gallons an hour and discharges onto Otter Road in NE.  $\frac{1}{4}$  sec. 34, tp. 10. Another spring in NW.  $\frac{1}{4}$  sec. 33, tp. 10 flows at a rate of more than 16,000 gallons a day.

#### Recovery of Ground Water

Ground water is recovered by means of springs, dug and drilled wells. Dug wells excepting where Whatcom stony clay is shallow do not yield sufficient water for a continuous supply. Where drilled wells encounter aquifers underlying Whatcom stony clay their depths are less than 200 feet. One well, failing to encounter a suitable aquifer underlying Whatcom stony clay, was drilled to a depth of 434 feet, (see log, page 36). In the northeast part of the area where Whatcom and possibly Newton stony clays may be as much as 300 feet thick and no sands of any extent exist between them, it might be advantageous especially for stock, to build dugouts in the impervious clays where run-off could collect.

#### FORT LANGLEY UPLAND

The Fort Langley upland is an island of Abbotsford outwash

surrounded by Fraser flood plain deposits. It reaches elevations of 50 feet or more above the surrounding plains. The area is less than 1 square mile. Ground-water reservoirs underlying this upland are probably recharged by water from Fraser River. Wells are dug or drilled up to 85 feet deep and the static level of the water in these conforms with the level of water in Fraser River and the water-table exposed in gravel pits along the southeast side of the upland. The water-table arches slightly under the upland and in the vicinity of the Fort Langley school is about 47 feet below the land surface whereas at the gravel pit it is 6 feet lower. Ground water in perched bodies on the west side of the upland and at lower elevations is high in iron probably due to infiltration of water from Salmon River. A properly developed well drilled to a depth of less than 100 feet in this upland might yield an abundance of water for municipal use as excessive pumping would filter water from the river through the gravel and sand.

#### LANGLEY LOWLAND

The ground-water reservoirs of Langley Lowland are perched flowing artesian aquifers made up of lenses of coarser silts and sands within the Cloverdale sediments. The aquifers are not continuous but are connected by finer silts that are pervious. Wells are commonly shallower along the sides of the valleys and are deepest along Glover Road. Neighbouring wells may differ as much as 100 feet in depth and in rate of flow from less than 1 gallon to 25 gallons a minute. The hydrostatic head ranges from a few inches to 20 feet.

Water from aquifers in the upland areas bordering the valley moves underground to recharge the coarser lenses of silt and sands within the Cloverdale sediments (4) and the pre-Vashon sands. Flowing artesian wells along the borders of this lowland are shallow, less than 100 feet, and have hydrostatic heads of 20 feet or more. Deeper drilling to 917

feet has not penetrated the sediments in this lowland although 900 feet of Cloverdale sediments (4) were penetrated before encountering coarse water-bearing sands.

About 130 wells have been recorded in Langley Lowland and there are many more. These wells, assuming a rate of flow of 10 gallons an hour, would waste 31,000 gallons a day which is a relatively low estimate.

The ground water is recovered by means of flowing wells the diameters of which are less than 3 inches. Larger diameter wells drilled by means of cable tool rigs may be expected to flow at rates of more than 100 gallons per minute, especially if such wells are drilled to the coarse gravels underlying the Cloverdale sediments.

#### GLEN VALLEY

The main aquifers in Glen Valley are lenses of sand within Cloverdale sediments (4) but shallow bodies of ground water are also present in the surface Fraser flood plain deposits (10). A perched ground-water body in a deposit of Abbotsford outwash (9) in sec. 29, supplies in the order of 4,000 gallons a day for stock use. Springs along the rim of the valley, as well as gravel benches, are sources of abundant ground water.

#### USE OF GROUND WATER

Ground water furnishes the principal domestic, industrial and public water supply for Langley municipality. As public knowledge concerning the presence and development of this important resource increases greater and more effective use will be made of ground water.

It is estimated that in Langley municipality 80 per cent of the wells are dug, 18 per cent are drilled or driven, and the remaining 2 per cent utilize natural flow of ground water from springs. The present use of ground water is largely for domestic and stock supplies and some 2 million gallons a day are consumed. Industrial use is limited to dairies, hatcheries and small industries. Two private wells at Aldergrove supply 70 family units with domestic water. Langley has private wells with, in some cases, two or more families using the same well.



### DEVELOPMENT OF ADDITIONAL GROUND-WATER SUPPLIES

The direct infiltration of rainfall is in excess of present rate of use of ground water. More ground water is available for development especially in Campbell Upland and Fort Langley Upland where developed wells may be expected to yield in the order of 400 to 500 gallons a minute. Elsewhere wells can be expected to yield sufficient supplies for farm needs. The main aquifers in the uplands are the Abbotsford outwash (9) and Huntingdon gravel (5) and in the lowland areas supplies of flowing artesian water are available from the Cloverdale sediments (4), that in Langley Lowland are as much as 900 feet deep. The outwash deposits are at or near the surface and ample supplies of ground water are available from shallow wells but where large supplies are required as for irrigation a drilled well properly equipped with a screen is recommended. Huntingdon gravel (5) that underlies Whatcom stony clay (7) is a probable source of ground water where outwash deposits are lacking at or near the surface.

In some areas on Clayton and Langley Uplands the underlying succession of strata is such that suitable ground water is difficult to locate within reasonable depths. Most of the wells are in stony clay, are shallow and commonly dry in summer months. The situation may be due to lack of exploratory drilling, test holes abandoned at shallow depth or improper development of aquifers encountered. Deeper wells drilled in these upland areas have established the presence of sufficient ground water at depths of 250 to 500 feet. In most cases the costs of drilling such wells cannot be borne by the individual. Where costs of drilling a well are excessive for the farm income, collection of surface run-off in dugouts would provide water in pasture-lands for stock.

From the records and tests of wells drilled there appears to be ample ground water in Langley municipality. By careful planning, ground water supplies could be developed to meet increased demands for water for farm, domestic, irrigation, municipal and industrial use that may be made in the future.

Pumping tests to determine the safe yield of an aquifer should be carried out before irrigation systems are set up on any well. Wells dug or drilled should be properly constructed as such wells may have a useful life of at least 50 to 100 years.

CHAPTER VI

QUALITY OF WATER

The analytical results of 15 samples of ground water collected in Langley municipality are given in the table on page 34. The samples were collected from the different water-bearing formations and are believed to represent the various types of ground water available in the municipality. The analyses were made by the Mines Branch, Dept. of Mines and Technical Surveys, Ottawa.

The results indicate that good quality soft water is available from the water-bearing formations. Water from aquifers underlying the stony clays and tills have a larger proportion of sodium and bicarbonate.

CHEMICAL CONSTITUENTS IN RELATION TO USE

Hardness.

Hardness presents one of the most important problems in the use of water. Soap, instead of forming a lather, reacts with calcium and magnesium bicarbonates and sulphates to form an insoluble curd. Thus, in hard water much soap is used in softening the water before advantage can be taken of its cleaning and lathering properties.

The hardness of a water is reported as parts per million  $\text{CaCO}_3$ . The total hardness is divided into carbonate hardness, also called temporary hardness, and non-carbonate or permanent hardness. Carbonate hardness is caused by the bicarbonates of calcium and magnesium and can be removed by boiling.

Water having a total hardness of less than 50 ppm. is considered soft and needs no treatment. A hardness of between 50 and 150 ppm. is satisfactory for most uses, but it increases soap consumption and causes considerable boiler scale. The aquifers yield soft water; only one sample analysed has a hardness over 100 ppm. The total hardness in all but one sample is that of the carbonate or temporary nature and can be reduced by boiling the water.

### Silica (SiO<sub>2</sub>).

Silica has a detrimental effect in some industrial uses, especially in boiler operation where it leads to the formation of hard silicate scales and acts as a cementing agent for softer carbonate scales. The ground water samples show a range in silica from 14 to 35 ppm., and normally surface waters are said to show a silica range of 10 to 30 ppm. The silica content of ground water in Langley municipality would not cause significant trouble to boilers.

### Calcium (Ca).

Calcium is usually present as calcium bicarbonate and its presence is due to the action of carbon dioxide and water on limestone, gypsum, and dolomite. In Langley municipality the ground water obtains its calcium from limestone in the glacial drift that was eroded and transported by glaciers to the municipality from areas outside the lower Fraser Valley. Some calcium may be obtained from fossil beds that contain shells with a high calcium content. These fossil beds occur in silts and clays in the unconsolidated deposits of the municipality. The calcium content of the ground water analysed ranges from 45 ppm. to 27.8 ppm.

### Magnesium (Mg).

Magnesium, like calcium is derived from dolomite by the same action of carbon dioxide and water. However, magnesium is lower in the samples analysed and this is probably due to the fact that dolomite is not found in the mountain areas bordering the lower Fraser Valley. Sea water is also a probable source of magnesium.

### Sodium (Na) and Potassium (K).

Sodium and potassium are the principal alkalis determined in the water analysis. They are present as chloride, sulphate and bicarbonates. Their sources are rock salt, interbedded with or disseminated through sedimentary bedrock formations; sea water, either directly or from that enclosed in sediments of marine origin; feldspars and certain other sodium and potassium-bearing minerals. A high percentage of sodium in water used for irrigation affects both the crops and the soil to which the

water is applied. However, high percentages of sodium can be tolerated if the dissolved solids are low as indicated in those samples analysed from water-bearing formations in Langley municipality.

Those ground waters that have percolated through the marine stony clays have a higher sodium content than ground water from other aquifers in Langley municipality.

#### Bicarbonate ( $\text{HCO}_3$ ).

Carbon dioxide dissolved in water renders the insoluble calcium and magnesium carbonate 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 side of cooking utensils.

#### Sulphate ( $\text{SO}_4$ ).

The main source of sulphate in ground water is gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) and metallic sulphide such as pyrite ( $\text{FeS}_2$ ). Pyrite is believed to be the chief source of the sulphate in Langley municipality. The sulphate content of the samples analysed ranges from 0 to 43.4, the higher sulphates being in ground water derived from the Cloverdale sediments and they may be in part derived from  $\text{H}_2\text{S}$  (hydrogen sulphide gas).

#### Chloride (Cl).

Chlorides are derived from organic materials or from sea water either directly or indirectly. In those samples analysed the chloride content is noticeably higher in the ground water from aquifers in the lowland areas that were deposited in embayments of the sea at an earlier geological time. Ground water of the upland areas especially areas of outwash are low in chlorides and the source of those present is probably organic. More than 300 ppm. are required to impart the salty taste to water.

#### Fluoride (Fl).

The source of fluorides are rocks and soils containing varying amounts of fluorine. Within recent years the importance of fluorides in connection with tooth decay has been investigated in many cities either with natural fluoride or the introduction of fluorides in the city water supply.

A fluoride concentration of less than 1.5 ppm. is considered beneficial to the calcification of teeth in children.

Nitrate ( $\text{NO}_3$ ).

Most nitrates found in ground water are due to the presence of vegetable or animal matter. Nitrates in larger amounts, more than 10 - 20 ppm., commonly indicate pollution of considerable extent. Therefore, a high nitrate concentration should necessitate an investigation of all possible sources of pollution.

ANALYSES OF WELL WATERS FROM LANGLEY MUNICIPALITY, B. C.

Owner	Location 1/4 Sec.	Tp.	Sum of Constituents	SiO <sub>2</sub> (Col)	Ca	Mg	Na	K	HCO <sub>3</sub>	SO <sub>4</sub>	Cl	Fl	NO <sub>3</sub>	Hardness as CaCO <sub>3</sub>		
														Total CO <sub>3</sub>	Non-CO <sub>3</sub>	
Super Valu	NE 2	8	679.6	43	11.1	5.9	224	7.6	212	44	228	0.1	6.0	52	52	0.0
D. Peacock	NE 3	8	641	34	12.6	5.7	216	14	222	43.4	201	0.2	0.8	54.9	54.9	0.0
W.M. Jensen	NW 7	10	247	35	7.2	2.6	80.2	1.8	236	0	2.1	1.0	0.8	28.7	28.7	0.0
D.C. Derksen	SW 3	10	245	20	4.5	1.3	86.8	2.7	249	3.1	2.3	0.5	0.8	16.6	16.6	0.0
B. Greer	SE 26	10	105.3	31	13.5	6.7	5.9	1.7	90.0	0	1.1	0.1	0.6	61.2	61.2	0.0
D.W. Poppy	NW 26	10	78.8	27	9.0	4.9	3.9	1.1	60.5	0.4	1.4	0	1.6	42.4	42.4	0.0
C. Ooms	NW 28	10	63.0	24	7.3	2.7	4.1	0.5	46.0	0.5	0.7	0.1	0.2	29.3	29.3	0.0
Maple Leaf Hatchery	NE 31	10	409	34	5.9	0.3	154	3.8	397	1.1	1.9	0.8	1.2	16.0	16.0	0.0
P.Y. Porter	NW 31	10	175.2	29	27.8	10.5	13.6	3.3	163	6.4	2.9	0.0	0.8	112.5	112.5	0.0
Anderson Engineering Co.	NW 32	10	200	20	11.1	6.0	52.8	5.5	197	2.8	1.4	0.3	0.2	52.4	52.4	0.0
A.C. Taylor	NW 17	11	408	22	11.0	4.0	138	4.9	242	20.5	80	-	1.2	43.9	43.9	0.0
C.E. Hall	SE 26	11	150	19	11.9	5.2	29.1	5.4	114	14.2	8.3	0.1	0.4	51.1	51.1	0.0
Fort Langley School	SE 32	11	134.3	14	14.3	3.9	23.8	1.0	39.0	8.2	34.1	0.04	16.0	51.7	51.7	0.0
B. Keet	SW 33	11	137.0	15	15.5	3.7	23.2	1.2	45.6	6.9	42.8	0.0	6.0	53.9	37.4	16.5
Naval Radio Station	NE 30	13	970.0	34	12.8	7.2	352	5.2	615	53.7	194	0.6	8.0	61.5	61.5	0.0

All figures are in parts per million

MATERIALS PENETRATED BY REPRESENTATIVE WELLS AND TEST HOLES  
IN LANGLEY MUNICIPALITY

Material	Thick- ness (feet)	Depth (feet)	Formation
Well No. 1, NE $\frac{1}{4}$ sec. 24, tp. 7			
clay, some stones	20	20	Whatcom and probably Newton stony clay
clay, silt, sand, boulders	37	57	Surrey till
sand	6	63	Quadra sediments
Well No. 1, NE $\frac{1}{4}$ sec. 2, tp. 8 Super Valu Store, Langley			
clay and silt	197	197	Cloverdale sediments
silt, lenses of fine sand	58	255	" "
sand, some gravel	50	305	" "
sand, coarse, gravel	1	306	" "
Well No. 2, SW $\frac{1}{4}$ sec. 22, tp. 8 (C.C. Heady)			
clay pebbles	20	20	Newton stony clay
clay, silt, sand, compact boulders	80	100	Surrey till
sand	20	120	Pre-Vashon
sand, fine, coarse at depth	102	222	Pre-Vashon
Well No. 1, SW $\frac{1}{4}$ sec. 25, tp. 8			
clay	28	28	Newton stony clay
clay, sand, boulders, compact	42	70	Surrey till
Drilling discontinued at 70 ft.			
Well No. 3, NW $\frac{1}{4}$ sec. 26, tp. 8			
clay	44	44	Whatcom and probably Newton stony clay
hardpan	10	54	Surrey till
sand, coarse	12	66	Pre-Vashon
sand, fine, water-bearing	27	93	" "
sand	12	105	" "
clay	2	107	" "
sand	5	109	" "
silt, clay	12	121	" "
sand	6	127	" "
Well No. 3, SE $\frac{1}{4}$ sec. 3, tp. 10			
clay, stones	55	55	Whatcom and possibly Newton stony clay
"hardpan"	30	85	Surrey till
gravel	1	86	Pre-Vashon
Well No. 3, NW $\frac{1}{4}$ sec. 7, tp. 10			
clay	65	65	Whatcom and possibly Newton stony clay
"hardpan"	65	130	Surrey till
sand, dry	30	160	Pre-Vashon
sand, gravel	14	174	" "



Material	Thick- ness (feet)	Depth (feet)	Formation
Well No. 2, SE $\frac{1}{4}$ sec. 26, tp. 10			
clay	50	50	Whatcom and possibly Newton stony clay
"hardpan"	90	140	Surrey till
sand, fine to medium	38	178	Pre-Vashon
gravel	2	180	" "
Well No. 3, SE $\frac{1}{4}$ sec. 26, tp. 10			
clay	85	85	Whatcom and possibly Newton stony clay
"hardpan"	26	111	Surrey till
sand and clay	49	160	Pre-Vashon
sand and gravel	19	179	" "
Well No. 1, NE $\frac{1}{4}$ sec. 31, tp. 10 (Maple Leaf Hatchery)			
clay	50	50	Whatcom and possibly Newton stony clay
"hardpan"	40	90	Surrey till
clay, fine sand	20	110	Semiamu sediments
"hardpan"	60	170	Semiamu till
gravel	6	176	Quadra
Well No. 3, NW $\frac{1}{4}$ sec. 17, tp. 11 (A.C. Taylor)			
silt, clay pebbles, water at 659 ft.	659	659	Cloverdale sediments
silt and clay compact	65	724	" "
gravel and sand, dirty	2	726	" "
sand, gravel, salty water	6	732	" "
sand, fine	23	755	" "
sand, fine, silt and clay	76	831	" "
clay	4	835	" "
sand, fine, silty, clay bits of wood, salty water	55	890	" "
sand and gravel	10	900	" "
gravel, coarse, water	5	905	" "
gravel, very coarse, water flows at rate of 100 g.p.m.	12	917	" "
Well No. 1, NE $\frac{1}{4}$ sec. 30, tp. 13 (Aldergrove Naval Radio Station)			
clay, brown to grey	46	46	Whatcom stony clay
sand, gravel, some water at 58 ft.	19	65	Huntingdon gravel
clay, sticky blue	186	251	Newton stony clay
boulders, gravel, sand, clay	78	329	Surrey till
sand and gravel, loose	7	336	Semiamu sediments
boulders, gravel, sand, clay	20	356	Semiamu till
sand, loose, water, sandy clay	128	484	Quadra sediments

## COMPILATION OF WELL DATA

The following information and abbreviations pertain to the well records of Langley municipality.

### Description of Well

#### Type of well

- Dr - drilled, well made by standard drilling rig.
- Dn - driven (sandpoint)
- Dg - dug or hand augered
- Br - well bored by power-driven auger
- Sp - spring

#### Type of casing

- C - concrete
- I - standard galvanized iron pipe
- S - standard black pipe
- W - wood cribbing
- T - till

#### 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 writer or that reported and believed reliable.

Sd - sand  
Gr - gravel  
Bd - boulders  
St - sandy till  
Si - silt  
F - fine  
Cs - coarse

Formation

Ab - Abbotsford  
Cl - Cloverdale  
F F - Fraser Flood plain deposits  
Hn - Huntingdon  
P V - Pre-Vashon  
Sm T - Sumas Till  
Ss - Sunnyside  
Sr T - Surrey Till

Water.

Use

Dm - domestic  
Ir - irrigation  
St - stock  
In - industrial  
C O - cooling purposes only  
N U - not used  
D H - dry hole

Yield.

Gals/hr. imperial gallons per hour.

Not all the yields reported were measured by the writer, some were reported by the well owners and believed reliable.

REPRESENTATIVE WELL RECORDS OF LANGLEY MUNICIPALITY, BRITISH COLUMBIA

LOCATION WELL NO.				DESCRIPTION OF WELL				PRINCIPAL AQUIFERS				WATER		YIELD	REMARKS
Sp.	Sec.	Twp.	No.	Type	Casing, diam. (inches)	Depth (feet)	Collar Elev. (feet)	Static Level (feet)	Depth to top (feet)	Character of material	Formation	Quality	Use	(gals hr.)	(16)
7	2	SE	1	Dg	48	26	292	16	25	Sd gr	P V	Clear, soft	Dm St	-	Seasonal Fluctuations
7	10	NE	1	Dg	60	42	260	20	12	S t	Sr T	Hard	Dm	-	Limited supply from sand lens in Surrey till
7	13	SE	1	Dr	3	72	245	15?	---	Sd	P V	Clear, soft	Dm	-	
7	13	NW	2	Dg	48	8.5	180	5	0	Gr	Ab	Clear, soft	Dm	-	
7	14	SE	1	Dr	4	115	215	20	60,80	Sd	P V	Clear, soft	Dm	360	Fine sand filled in bottom of well from 90-115 ft
7	14	NW	2	Dn	14	32	165	15	0	Sd gr	Ab	Clear, soft	Dm St	-	
7	14	NE	3	Dg	36	13	180	8	0	Sd gr	Ab	Clear, soft	Dm	-	
7	15	NE	1	Dn	2	22	165	18	0	Sd gr	Ab	Clear, soft	Dm St	-	
7	15	SE	2	Dg	48	22	185	14	0	Sd gr	Ab	Clear, soft	Dm St	-	
7	15	SE	3	Dr	4	134	170	104	130?	Gr	P V	Clear, soft	Dm	-	Drilled 1955 log incomplete
7	22	NE	1	Dn	14	24	164	15	0	Sd gr	Ab	Clear, soft	Dm St	-	
7	22	SE	2	Dn	2	24	164	14	0	Sd gr	Ab	Clear, soft	Dm Ir	-	
7	22	SE	3	Dn	14	15	157	14	0	Sd gr	Ab	Clear, soft	Dm Ir	-	
7	23	SE	1	Dg	36	12	175	7	0	Sd gr	Ab	Clear, soft	Dm	-	
7	23	NW	2	Dg	60	24	166	10	0	Sd gr	Ab	hard	Dm St	-	
7	24	NE	1	Dr	4	63	190	20	57	Sd	P V	Good, clear	Dm St	-	Drilled 1954; see log
7	24	SW	2	Dg	36	12	180	9	0	Sd gr	Ab	Good, clear	Dm	-	
7	24	NE	3	Dr	4	94	175	10	---	F sd	P V	Clear, clear	Dm	-	
7	25	NW	1	Dg	48	21	170	14	0	Sd gr	Ab	Soft, clear	Dm	-	
7	26	NW	1	Dr	36	30	160	12	0	Sd gr	Ab	Soft, clear	Dm	-	Well at Belmont School
7	27	SE	1	Dg	36	25	164	12	0	Sd gr	Ab	Soft	Dm St	-	
7	34	NE	1	Dg	36	12	110	5	0	Sd gr	Ab	Soft	Dm St	-	
7	34	NE	2	Dg	60	40	110	36	0	Sd gr	Ab	Soft	Dm St	-	
7	34	NE	3	Dg	30	36	140	31	0	Sd gr	Ab	Soft	Dm St	-	
7	34	SE	4	Dn	4	45	140	40	0	Sd gr	Ab	Soft	Dm St	-	
7	34	SE	5	Dg	36	51	140	48	51	Sd gr	P V	Soft	Dm Ir	-	
7	35	NE	1	Dg	36	36	150	30	0	Sd gr	Ab	Soft	Dm	-	
7	36	SE	1	Dg	48	13	160	7	0	Sd gr	Ab	Soft	Dm	-	
7	36	SE	2	Dr	6	90	160	45	---	---	---	Soft	Dm St	-	Log incomplete

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
8	1	SE	1	Dr	I	2	240	40	+ 20	240	F sd	Cl	Dm	120	Temp. of water 52°F.
8	1	SE	2	Dr	I	2	282	39	+ 26	280	Sd	Cl	Dm	180	Natural flow
8	1	SW	3	Dr	I	2	359	60	+ 2	358	Sd	Cl	Dm	150	Natural flow
8	2	NE	1	Dr	S	4	306	30	?	306	Sd gr	Cl	Dm	27	See log; see analysis. Well at Super Valu Market
8	2	NW	2	Dr	I	2	254	30	+ 15	240	Gr	Cl	Dm	154	Temp. of water 50°F.
8	3	NE	1	Dr	S	4	350	42	+ 1	340	Sd	Cl	Dm	300	Temp. of water 50°F. See analysis
8	3	NE	2	Dr	I	1.5	311	25	+ 15	300	Gr	Cl	Dm	60	Supplies 5 houses
8	3	SE	3	Dg	C	36	9	60	- 2	0	Sd	Ss	Dm St	50	Perched water-table well
8	3	SW	4	Dr	I	4	165	30	+ 1	100	Sd gr	Cl	Dm St		Natural flow
8	10	NE	1	Dr	I	2	88	60	0	80	Sd gr	Cl	Dm St	40	Natural flow
8	10	SE	2	Dr	I	1.5	197	45	0	194	Cs sd	Cl	Dm St	20	Natural flow
8	10	SE	3	Dr	I	2	260	30	+ 2	160	Gr	Cl	Dm Ir		
8	10	SW	4	Dn	I	2	61	70	+ 1	60	Gr	Cl	Dm St	---	
8	10	NW	5	Dg	C	24	22	100	- 20	20	Sd gr	P V	Dm St	---	Log incomplete
8	10	NW	6	Dr	I	3	240	144	- 60	---	Sd gr	P V	Dm St	---	
8	10	NW	7	Dr	I	5	50	132	- 44	40	Sd gr	P V	Dm St	---	
8	11	NE	1	Dr	S	2	282	46	+ 5	282	Sd gr	Cl	Dm St	120	Drilled 5 holes all yielded poor water
8	11	NW	2	Dr	I	2	255	65	+ 6	255	Sd	Cl	Dm St	40	Temp. of water 50°F.
8	12	SE	1	Dr	S	3	350	33	+ 3	350	Sd	Cl	Dm	60	Temp. of water 50°F. well at Exhibition Grounds
8	12	NE	2	Dr	I	2	590	26	+ 20		Sd?	Cl	Dm	52	Log incomplete
8	13	SE	1	Dr	S	2	353	38	+ 15?		---	Cl	In	2400	Well at Wishing Well Bev. Co.
8	14	SW	1	Dr	S	4	108	74	- 8	100	Gr	P V	Dm St	---	Temp. of water 48°F.
8	15	NE	1	Dg	C	36	45	140	- 30	45	Gr	P V	Dm St	---	
8	15	SE	2	Dg	C	48	27	150	- 23	---	Gr	P V	Dm St	---	Log incomplete
8	15	SE	3	Dr	I	3	240	63	0	190	Gr	P V	Dm St	---	Log incomplete
8	15	SW	4	Dg	C	48	21	120	- 19	21	Sd	P V	Dm St	---	Log incomplete
8	22	NE	1	Dr	S	4	180	222	- 100	80, 180	Sd	P V	Dm St	---	Log incomplete. A log of wood encountered at elevation 47 ft.
3	22	SW	2	Dr	S	8	222	257	- 158	208, 220	Sd	P V	Dm St		See analysis
3	24	SE	1	Dr	S	2	148	47	+ 5	---	Sd	Cl	Ir	4800	See log
3	24	SE	2	Dr	S	3	36	60	+ 8	36	Sd gr	Cl?	Dm St	60	Natural flow
3	24	NE	3	Dr	S	6	132	---	---	---	---	---	Dm St	270	Temp. of water 50°F.
8	24	SE	4	Dr	S	4	52	73	?	---	Sd gr	P V	Dm St	180	Drilling discontinued at 132 ft.

! 50 !

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
8	25	SW	1	Dr	S	70	249	---	---	---	---	Soft	N U		
8	26	NE	1	Dr	C	157	190	117	50	F sd	P V	Soft	Dm St		
8	26	NW	2	Dg	S	63	140	60	---	F sd	P V	Soft	Dm St		
8	26	NW	3	Dr	S	127	135	28	---	F sd	P V	Soft	Dm St		
8	27	NE	1	Dr	I	120	75	0	100	Sd	---	Soft	Dm St	75	
8	27	SW	2	Dg	-	23	148	20	18	Gr	P V	Soft	Dm St		
8	27	SW	3	Dg	-	40	182	35	40	Gr	P V	Soft	Dm St		
8	27	SW	4	Dg	C	8	69	7	0	Sd	Ss	Soft	Dm St		
8	27	NW	5	Dg	C	9	50	7	0	Sd	Ss	Soft	Dm St		
8	34	NE	1	Dg	C	14	40	10	8	Gr	P V	Soft	Dm St		
8	34	SE	2	Dg	C	9	79	7	0	Sd	Ss	Soft	Dm St		
8	35	NE	1	Dn	---	9	86	8	0	Sd	Ss	Soft	Dm St		
8	35	SW	2	Dr	---	44	50	4	40	Sd	---	Sulphur	Dm St	40	
8	36	NE	1	Dr	I	480	50	---	230, 260, 280	Sd	---	Good	Dm St		
9	1	SE	1	Dr	I	550	52	10	---	Sd	---	Salty	C		
9	2	SW	1	Dg	T	16	28	13	---	Gr	Ab?	Soft	Dm		
9	2	NE	2	Dg	C	12	10	9	0	Gr	F F	Soft	Dm		
9	3	NE	1	Dg	C	7	13	5	0	Gr	F F	Soft	Dm St	10,000	
9	3	SE	2	Dg	C	10	48	6	5	Gr	Ab	Soft	Dm		
9	3	SW	3	Dg	C	12	47	6	0	Gr	F F	Soft	Dm		
9	12	NE	1	Dg	C	18	10	15	0	Si sd	F F	Soft, iron	Dm		
10	1	SW	1	Dg	C	12	168	8	---	Gr	Ab	Clear, good	Dm		
10	3	SE	1	Dr	S	120	252	30	---	Sd	Hn?	Clear, good	Dm St		
10	3	SE	2	Dr	S	87	217	16	86	Sd	Hn?	Clear, good	Dm St		
10	3	SE	3	Dr	S	86	211	10	55, 85	Gr	Hn?	Clear, good	Dm St	150	
10	6	NE	1	Dg	C	54	237	42	54	Gr	Hn?	Soft	Dm St		
10	7	SW	1	Dr	S	100	235	91	95	Gr	P V	Soft	Dm St	200	
10	7	NW	2	Dr	S	150	319	144	149	Bd	P V	Soft	---	152	
10	7	NW	3	Dr	S	174	356	160	160	Gr	P V	Yellow in colour	Dm St		

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
10	8	NW	1	Dr	S	4	260	- 50	98	Gr	P V	Yellow in colour	Dm St		
10	8	SW	2	Dr	S	5	260	---	186	Gr	P V	Yellow in colour	Dm St		
10	9	SE	1	Dr	S	4	260	- 57	---	Gr	P V	Clear, good	Dm St		
10	14	SW	1	Dr	S	4	229	- 40	45, 89	Gr	Hn?	Iron	Dm		Well was drilled 115 feet, filled with sand to 90 feet. Water from sand at 45 and 89 feet
10	14	SE	2	Br	W	24	281	- 42	82	F sd	Hn?	Soft, clear	Dm St		
10	14	NE	3	Dg	W	60	289	- 25	90	Sd	Hn?	Soft, clear	Dm St		
10	15	SW	1	Dr	S	4	264	- 36	54	Sd	P V	Soft, clear	Dm St		
10	16	NE	1	Dr	S	4	346	- 102	110	Sd	P V	Soft, clear	Dm		
10	16	SE	2	Dr	S	4	286	---	---	Sd	P V	Good, clear	Dm St		
10	17	SE	1	Dr	S	5	266	- 40	100, 186	Sd	P V	Good, clear	Dm	420	
10	17	SW	2	Dr	S	4	251	---	186	F sd	P V	Yellow in colour	Dm St		
10	17	SW	3	Dr	S	5	257	---	---	Sd	P V	Yellow in colour	Dm St		
10	17	NW	4	Dr	S	4	259	- 60	150	Sd	P V	Yellow in colour	Dm St		Uses 1,000 gallons a day
10	17	NE	5	Dr	S	4	256	- 32	110	Sd	P V	Yellow in colour	St		Water has a sulphur odour
10	18	SE	1	Dr	S	4	252	- 50	150	Gr	P V	Good, clear	Dm		Test pumped for a period of 24 hours no record kept
10	18	SE	2	Dr	S	5	324	- 131	140	Gr	P V	Good, clear	Dm St		
10	19	SE	1	Dr	S	5	300	---	---	---	---		D H		Some water at 221 feet, but pumped out in 15 minutes
10	22	NE	1	Dr	S	5	420	---	---	F sd	Hn	Iron	D H		
10	25	SE	1	Dr	S	4	364	---	---	---	---		Dm		
10	25	NW	2	Dr	S	4	380	- 50	90	Sd	Hn	Good, clear	Dm		Water in sand below stony clay
10	25	NW	3	Dr	S	4	354	- 85	136	Sd	Hn	Good, clear	Dm St		
10	26	SE	1	Dr	S	4	420	- 130	178	Gr	Hn	Good, clear	D H		Hole not drilled to aquifer, should be deepened
10	26	SE	2	Dr	S	4	411	---	160	Gr	Hn	Good, clear	Dm St		See log
10	26	SE	3	Dr	S	5	391	---	---	---	Hn	Good, clear	Dm		See log
10	26	SW	4	Dr	S	6	339	- 70	99	Sd	Hn	Good, clear	Dm		

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
10	26	NW	5	Dr	S	6	171	360	116, 145 170	Gr	Hn?	Good, clear	Dm St	300	See analysis
10	26	NW	6	Dg	W	48	12	348	5	Gr	Ab	Good, clear	Dm		A water-table well
10	26	NW	7	Dg	C	36	60	332	58	Gr	Hn?	Good, clear	Dm		
10	26	NE	8	Dr	S	4	122	350	114	Sd	Hn	Good, clear	Dm St		Water in sand below stony clay
10	26	NE	9	Dr	S	4	100	384	70	Sd	Hn	Good, clear	Dm St		
10	27	SE	1	Dr	S	10	300+	425	---	---	---	---	Dm St		Well at Otter Farmer's Institute, drilled originally in search of oil. Supplies 7 farms besides the Institute
10	27	NE	2	Dg	C	42	13	328	10	Gr	Ab	Good, clear	Dm		Log incomplete
10	27	NE	3	Dr	S	4	110	334	85	---	---	Good, clear	Dm		
10	27	NE	4	Dr	S	3	76	332	64	F sd	Hn	Good, clear	Dm		
10	27	NE	5	Dr	S	4	80	326	63	Gr	Hn	Good, clear	Dm	800	Test pumped at rate of 800 gals./hr. for 21 days
10	27	NW	6	Dr	S	4	76	329	64	Sd	Hn	Good, clear	Dm		
10	27	NW	7	Dr	S	5	90	320	88	Sd	Hn	Good, clear	Dm		Uses 1,000 gals/day
10	28	SE	1	Dr	S	4	94	343	74	Sd	Hn	Good, clear	Dm St		Log incomplete
10	28	SE	2	Dr	S	4	78	312	42	Sd	Hn	Good, clear	Dm St		Water in sand below stony clay
10	28	NW	3	Dr	S	4	90	345	76	Gr	Hn	Good, clear	Dm		See analyses
10	30	NE	1	Dr	S	4	156	184	14	Sd	P V	Good, clear	Dm St	30	Water flows over top of casing at ground surface
10	30	SW	2	Dr	S	4	60	150	---	Sd	Hn?	Good, clear	Dm St		See log; see analyses
10	31	NE	1	Dr	S	4	176	202	26	Gr	P V	Good, clear	Dm		See analyses
10	31	NW	2	Dr	S	2	72	70	45	Gr	Cl?	Good, clear	Dm		Log incomplete
10	31	NW	3	Dr	S	5	136	140	11	---	---	Good, clear	Dm		Gravel below 11 feet of clay
10	32	SE	1	Sp	-	48	11	230	Surface	Gr	Hn	Clear, good	Dm St		Decreases seasonally
10	32	SE	2	Dg	-	57	57	229	5	Gr	Hn	Clear, good	Dm St		Well at Langholm
10	32	NW	3	Dr	S	5	107	225	3	Sd	Hn	Clear, good	Dm		Log incomplete
10	32	NW	4	Dr	S	4	137	209	---	Sd	Hn	Clear, good	Dm St	150	See analyses; 20 gal/hr. at 80 feet
10	32	NW	5	Dr	S	4	136	212	20	Sd	Hn	Clear, good	Dm		Not sufficient, well at Auto court
10	32	NW	6	Dr	S	6	111	212	60	---	---	Clear, good	Dm		Water in sand below 42 feet of stony clay
10	32	NE	7	Dr	S	4	42	223	Surface	Sd	Hn	Clear, good	Dm St		Drilled July 1955
10	32	NE	8	Dr	S	4	52	205	Surface	Sd	Hn	Clear, good	Dm		Supplies 20 people
10	33	SE	1	Dg	-	48	70	326	66	Sd	Hn	Clear, good	Dm		Log incomplete
10	33	SE	2	Dr	S	5	110	330	85	---	---	Clear, good	Dm		Lens or pod of gravel in Surrey Till?
10	33	SW	3	Dg	C	32	39	269	36	Gr	Hn	Clear, good	Dm		
10	33	NW	4	Sp	---	---	---	233	Surface	Sd	Ab	Clear, good	Dm		
10	33	NW	5	Sp	---	---	---	242	Surface	Sd	Ab	Clear, good	Dm		Water rights posted 16,000 gals./day



(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
10	33	NW	6	Dg	---	43	266	-	40	0	Sd gr	Ab	Clear, good	Dm	Water first at 25 ft.
10	33	NW	7	Dg	W	23	271	-	13	0	Sd gr	Ab	Clear, good	Dm	
10	33	NE	8	Dg	C	36	277	-	33	0	Gr	Ab	Clear, good	Dm	Log incomplete
10	34	SE	1	Dr	S	6	315	-	80	65	F sd	Hn	Clear, good	Dm	
10	34	NW	2	Dg	C	36	276	-	12	0	Gr	Ab	Clear, good	Dm St	
10	34	NE	3	Sp	---	---	261	Surface		0	Sd gr	Ab	Clear, good	Dm St	Temp. of water 47°F.
10	36	NE	1	Dr	S	4	344	-	70	---	Sd	Hn	Clear, good	Dm	
10	36	NE	2	Dr	S	4	334	-	32	---	Sd	Hn	Clear, good	Dm St	
10	36	NE	3	Dr	S	4	341	-	155	---	F sd	Hn	---	---	Well never developed
10	36	NW	4	Dg	C	36	290	-	8	0	Gr	Ab	Clear, good	Dm St	
11	1	NW	1	Br	C	36	313	-	42		Gr	Hn	Clear, good	Dm St	Supplies 6 families
11	3	NE	1	Dg	W	24	282	-	20	0	Gr	Ab	Clear, good	Dm St	
11	3	NW	2	Dg	C	36	282	-	48	0	Gr	Ab	Clear, good	Dm St	
11	4	SE	1	Dg	C	36	281	-	43	0	Gr	Ab	Clear, good	Dm	Drawdown exceeds 180 ft. Natural flow
11	4	NE	2	Dg	C	36	278	-	74	0	Gr	Ab	Clear, good	Dm	
11	5	SE	1	Dr	S	4	195	-	4	---	Gr	Hn	Clear, good	Dm St	
11	5	NW	2	Dr	S	4	114	-	50	---	---	---	---	---	Temp. of water 50°F. Well at Seal Cap Dairy
11	5	NE	3	Dr	S	2	96	+	15	Sd	Cl	Cl	Clear, good	Dm	
11	6	SE	1	Dr	S	4	199	-	51	Sd	Hn	Hn	Clear, good	Dm	
11	6	SE	2	Dr	S	6	204	-	50	---	F sd	P V?	Clear, good	Dm	Temp. of water 50°F. Temp. of water 50°F.
11	6	SW	3	Dr	S	2	40	+	12	220	Sd	Cl	Clear, good	In	
11	6	SW	4	Dr	I	1½	67	+	2	75	Sd	Cl	Clear, good	Dm	
11	6	NE	5	Dr	I	1½	67	+	9	42	Sd	Cl	Clear, good	St	Temp. of water 50°F. Natural flow.
11	6	NW	6	Dr	S	2	40	+	14	250	Sd	Cl	Clear, good	Dm	
11	7	SW	1	Dr	S	2	40	+	20	300	Gr	Cl	Clear, good	Dm St	
11	7	NW	2	Dr	S	3	46	---		290	Sd	Cl	Clear, good	St	Two wells each 300 ft. deep. Natural flow
11	8	SE	1	Dr	S	4	90	+	13	60	Sd	Cl	Clear, good	St	
11	8	NW	2	Dr	S	3	62	+	6	300	Sd	Cl	Clear, good	St	
11	10	SE	1	Dg	C	36	284	-	75	---	Gr sd	Ab	Good, clear	Dm St	Water in sand below stony clay Well drilled 1955
11	11	NE	1	Dr	S	4	276	-	15	35	Sd	Hn	Good, clear	Dm	
11	12	SW	1	Dr	S	4	310	-	147	F sd	F sd	Hn	Good, clear	Dm St	
11	12	SW	2	Dr	S	4	316	---		F sd	F sd	Hn	Good, clear	St	
11	12	NW	3	Dr	S	4	305	---		70	Gr	Hn	Good, clear	Dm St	
11	12	NW	4	Dr	S	4	286	-	15	49	Sd	Hn	Good, clear	Dm St	

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
11	12	NE	5	Dg	C	36	42	318	---	Sd	Hn	Good, clear	St		Well at County Line School
11	13	NE	6	Dr	S	4	55	339	---	Sd?	Hn	---	Dm		
11	13	SW	1	Dr	S	4	75	296	75	Sd	Hn	Good, clear	Dm St		
11	14	SE	1	Dr	S	4	60	299	---	Sd	Hn	Good, clear	Ir		
11	14	SE	2	Dr	S	4	60	290	---	Sd	Hn	Good, clear			
11	14	SW	3	Dg	C	32	68	253	---	Sd	Hn	Good, clear	Dm		
11	15	SW	1	Dg	C	36	55	183	---	Gr	Ab	Good, clear	Dm		
11	15	NW	2	Dr	I	3	76	183	---	Gr	Ab	Good, clear	Dm		Supplies 4 families.
11	16	NE	1	Sp	C	---	2	138	0	Sd	Ab	Good, clear	Dm		
11	17	SE	1	Dr	S	3 $\frac{1}{2}$	135	75	80	Sd	Cl	Good, clear	Dm St		Natural flow.
11	17	NE	2	Dr	I	2	285	72	---	Sd	Cl	Good, clear	Dm St	60	Temp. of water 49°F.
11	17	NW	3	Dr	S	10	917	51	900	Gr	Cl	Good, clear	Dm St	6,000	Temp. of water 56°F. See log.
11	18	SW	1	Dr	I	3	422	40	300	Gr	Cl	Good, clear		2,000	
11	18	SW	2	Dr	---	---	497	43	475	Sd	Cl	Good, clear		180	Salty water at 350 feet.
11	19	SE	1	Dr	I	2 $\frac{1}{2}$	360	35	360	Sd	Cl	Brackish	Dm	240	Temp. of water 48°F.
11	19	NE	2	Dr	I	1 $\frac{1}{2}$	325	30	300	Sd	Cl			360	Temp. of water 50°F.
11	20	SE	1	Dr	S	2	150	33	---	Sd	Cl	Good, clear	Dm	53	Temp. of water 49°F.
11	20	SW	2	Dr	S	2	456	43	---	---	Cl	Good, clear	Dm		Drilled 1955
11	21	SW	1	Sp	C	8	1 $\frac{1}{2}$	90	0	---	---	Good, clear	Dm	2	Temp. of water 47°F.
11	21	SW	2	Dr	I	2	165	74	---	Sd	Cl	Sulphur	Dm	48	Temp. of water 49°F.
11	22	SW	1	Dr	S	4	92	188	---	---	Hn	Good, clear			
11	22	SW	2	Dr	S	4	80	209	---	Gr	Hn	Good, clear			
11	22	NE	3	Dr	S	4	94	204	---	Gr	Hn	Good, clear			
11	22	NW	4	Dg	C	26	65	184	10	Sd	Hn	Good, clear			
11	22	NW	5	Dr	S	4	203	247	195	F sd	P V?	Good, clear		50	
11	24	SE	1	Dr	S	4	180	242		F sd	Hn	Dry hole			Well drilled 195, Sandpoint driven 8 feet into aquifer
11	25	SW	1	Dn	---	---	12	28	0	Sd	F F	Good, clear	Dm		Some water but couldn't develop
11	25	SW	2	Dg	C	36	13	33	0	Sd	F F	Good, clear	Dm		Well at East Langley School
11	26	SE	1	Dr	S	1 $\frac{1}{4}$	430	44	---	Gr	Cl		Dm St		Salt water at 200 ft. See analysis
11	26	SW	2	Dr	I	3	240	26	---	F sd	Cl	Good, clear	Dm St	5,600	Natural flow
11	29	SW	1	Dr	I	2	127	53	---	---	Cl	Good, clear	Dm	40	Temp. of water 52°F.
11	31	SW	1	Dg	I	48	30	100	0	Sd	Ss	Good, clear	Dm St		
11	32	SE	1	Dg	---	---	80	53	0	Gr	Ab	Good, clear	Dm		Well at Fort Langley School; see analysis

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
11	32	SE	2	Dr	S 5	55	---	---		Gr	Ab	Good, clear	Dm		Drilled August 1954
11	32	NW	3	Dn	---	30	17	---	0	Sd	F F	Rusty	Dm		
11	33	SW	1	Dg	C 30	63	54	- 57		Gr	Ab	Good, clear	Dm St		
11	33	SW	2	Dr	S 2	250	14	+		---	---		Dm		
11	33	NW	3	Dr	S 2	360	15	-		Sd	---	Good, clear	N U	25	Drilled 1909
11	33	SW	4	Dr	S 5	52	47	- 47	---	Gr	Ab	Good, clear			See analysis
12	5	SW	1	Dr	S 2	450	14	+		Sd	Cl	Good, clear	Dm St	52	Temp. of water 52°F. Salty water at 245 ft.
12	6	SE	2	Dr	S 2	347	17	---	325	F sd	Cl	Good, clear	Dm	30	Natural flow.
12	8	NW	1	Dg	W 48	22	20	- 6	---	Gr	F F	Good, clear	Dm St		
13	6	SW	1	Dg	C 36	12	178	- 5	11	Gr	Ab	Good, clear	Dm St	120	Natural flow. Well at Customs Bldg.
13	6	SW	2	Dr	S 6	106	139	Surface				Good, clear	Dm		Well at Patricia School
13	7	SW	1	Dg	C 36	15	266	- 12	---	Sd	Ab	Good, clear	Dm		Drilling discontinued.
13	8	NW	1	Dr	S 8	---	286	---		---	---		D		Sufficient for 2500 poultry.
13	18	NE	1	Dg	C 36	42	332	- 40		Sd	Ab	Good, clear	Dm St		Supplies 12 families at Auto court.
13	19	NE	1	Br	C 36	29	324	- 18	20	Sd	Hn	Good, clear	Dm		Aldergrove School Well, see analyses
13	19	NE	2	Dg	C 36	47	337	- 35		Sd?	Hn	Good, clear	Dm		Sandpoints driven into bottom of well Aldergrove
13	19	NE	3	Dg	C 36	45	339			Sd	Hn	Good, clear	Dm		Town well, supplies 70 families
13	20	NW	1	Dg	C 36	31	331	---	20	Sd	Hn	Good, clear	Dm		Seven sandpoints driven into bottom of well
13	20	SW	2	Dg	C 32	32	328	- 28	32	Sd	Hn	Good, clear	Dm		Aldergrove Town well
13	29	NW	1	Dr	S --	70	352	---	---	Sd	Hn	Good, clear	Dm		Water in sand below stony clay
13	30	NE	1	Dr	S --	484	358	---	356	See log	P V	Good	Dm		Log incomplete.
13	30	SE	2	Dg	C 36	15	349	- 14		Sd	Ab	Good, clear	Dm		See analysis, well at Naval Station, see log
13	32	NW	1	Dg	- 48	43	337	- 41	36	Sd	Hn	Good, clear	Dm		Water in sand below stony clay
14	6	NE	1	Dr	S 4	182	292	- 140	41	Gr sd	Hn	Iron	Dm		
14	6	NW	2	Dg	C 30	9	328	- 5	---	Sd	Ab	Good, clear	Dm		
14	7	SW	1	Sp	---	6	332	Surface	---	S t	Sm T	Good, clear	Dm		

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
14	7 NE		2	Sp	---	7	285	surface	---	S t	Sm T	Good, clear	Dm		
14	19 NE		1	Dg	C 30	8	11	---	0	Gr sd	F F	Good, clear	Dm		
14	20 NW		1	Dr	S 2	400	23	+ 18	---		Cl?	Good, clear	Dm St		Natural flow
14	29 SW		1	Dr	---	612	14	+ 29	---		Cl?	Good, clear	Dm St	200	
14	29 NW		2	Dg	W 48	18	19	- 9	---	Gr	Ab	Iron			4,000 gals. a day
14	30 NE		1	Dr	S 2	510	12	+ 18		Sd	Cl	Good, clear	Dm St	300	Temp. of water 51°F. natural flow.
14	30 NE		2	Dr	S 2	392	14	+ 20		Sd	Cl	Good, clear	Dm St	900	Natural flow
14	30 NE		3	Dr	S 2	450	12	+ 20		Gr	Cl				Natural flow
14	32 SW		1	Dr	S 2	290	20	+ 5		Sd	Cl	Good, clear	Dm St	75	Temp. of water 53°F.