

## **Aquifer Classification Worksheet for Colwood Delta Aquifer (682)**

Aquifer number: 682

Proposed name of aquifer: Colwood Delta Aquifer (682).

Aquifer Classification: IIIB(11).

### Descriptive location of aquifer:

The unconsolidated sand and gravel aquifer is found in the Colwood, Langford and Metchosin area, beginning north of Langford Lake, and encompassing the lowlands ( $\leq 75$  to 90 m elevation) surrounding Langford and Glen Lake. From here the deposit extends southeast to Esquimalt Lagoon and southwest toward Dewdney Flats in Sooke and Happy Valley in Metchosin. The sand and gravel deposit that makes up the aquifer can be observed at the Metchosin Gravel Pit operated by Construction Aggregates Ltd., on Metchosin Rd, southwest of Esquimalt Lagoon. The Colwood delta deposit has been mined as an aggregate source at the Metchosin gravel pit, and at now abandoned gravel pits at Royal Roads, south of Langford Lake (off Leigh Road), and north of Langford Lake (southeast of Lakehurst Drive).

Date: July 2004.

NTS mapsheet: 092B/05, 092C/06.

TRIM mapsheets: 092B.043.

### What geological formation does the aquifer belong to?

The aquifer is made up of layered sand and gravel from the Colwood Delta, deposited at the end of the Fraser glaciation c. 13,000 y BP by melt-water flowing from receding glaciers in the Goldstream River basin and Finlayson Arm, Saanich Inlet (Yorath and Nasmith, 1995; D.H. Huntley, 1995). The deposit is made up of hanging melt water channels, reworked till and terraced glaciofluvial outwash up to 20 m thick, including coarsening upward layers of sand and gravel interrupted by lenses or layers of silt or clay, and abandoned postglacial channel deposits (Huntley, 1995; Howes and Nasmith, 1983). At the time of the delta formation, sea level was thought to be up to 75 m higher than at present due to isostatic depression of the land surface; boreholes at the Metchosin gravel pit indicate the sand and gravel deposit extends up to 40 m below present sea level (Howes and Nasmith, 1983). As glacial ice receded from Finlayson Arm, remnant kettle deposits at Langford Lake, Glen Lake and Esquimalt Lagoon inhibited or diverted the flow of deltaic melt-water, reducing the thickness of sand and gravel deposited in these areas.

Well records indicate alternating layers, up to 10 m (25 ft) thick, of clean to silty, fine to coarse brown or grey sand and pea gravel, interrupted by brown or blue clay strata, and underlain by till. The sand and gravel unit declines in thickness or pinches out just north of Esquimalt Lagoon, where spring discharges flow overland and coalesce into ephemeral streams that drain from the sloped land surface seaward (Seacor Environmental Inc., 2003; Payne Engineering Geology, 1997; Payne Engineering Geology, 1996).

The Colwood Delta aquifer is underlain by Late Wisconsin till (26,000 to 10,000 y B.P.), by aquifer 606, made up of basalt and gabbro of the Metchosin Igneous Complex, and by aquifer 680, made up of igneous granitic bedrock of the Wark-Colquitz Complex (Huntley, 1995; Massey, 1994).

What type of aquifer is it (unconsolidated/bedrock? Confined/unconfined)?

The aquifer is a partially confined unconsolidated aquifer. Well records indicated confinement is provided by clay, till, silt or combined clay and till, observed in 53% of the well logs. These sediments are assumed to be Victoria clay (a glaciomarine silt and clay unit) and Capilano post-glacial sediments deposited at the end of the Fraser Glaciation (c. 13,000 to 5000 y BP) (Blyth and Rutter, 1993a). The surficial geology map describes the majority of the aquifer area, including around Langford and Glen Lakes, as being overlain by a blanket (> 1 m thick) of glacial diamicton; marine clay overlies the aquifer close to the coast at Esquimalt Lagoon; and in the Sooke/Dewdney Flats area, the glaciofluvial sands and gravels are confined by glaciolacustrine clay and silt (Blythe and Rutter, 1993a and 1993b). The quaternary geology map also confirms the existence of thicker marine clay overburden in the Esquimalt Lagoon area (Monahan and Levson, 2000). Well records show that the upper strata of the Colwood Delta contain silt and clay layers, which may provide additional confinement for underlying water-bearing sand and gravel.

How was the aquifer boundary delineated?

The aquifer boundaries were delineated based on the occurrence of sands and gravels identified as belonging to the Colwood Delta formation, as indicated on the surficial and Quaternary geology maps of the area, and upon the occurrence of wells constructed in the unconsolidated deposit. The marine coastline comprises the south-eastern boundary of the aquifer, from Albert Head to Gotha Point at Esquimalt Lagoon.

What is the size of the aquifer?      24.1 km<sup>2</sup>

What is the aquifer's productivity?

The productivity of the aquifer is considered moderate. The aquifer is made up of unconsolidated sand and gravel, typically associated with moderate to high water yields. The arithmetic mean, geometric mean and median estimated well yield (based on 7 wells or 21% of well records) are 1.6 L/s, 1.0 L/s and 0.76 L/s respectively (26 gpm, 15 gpm, and 12 gpm). The minimum

estimated well yield is 0.32 L/s (5.0 gpm) and the maximum estimated well yield is 6.3 L/s (100 gpm). Summary statistics of estimated well yield do not include monitoring wells in the Royal Roads and Esquimalt Lagoon area, for which yield has not been determined (Seacor Environmental Inc., 2003; Payne Engineering Geology, 1996). At the Construction Aggregates Ltd. gravel pit on Metchosin Rd. it is noted that a well constructed at the property in the 1950's or 1960's (actual date of construction unknown) was listed as yielding approximately 6.3 L/s (100 gpm); in comparison, wells constructed in 2001 yielded  $\leq 5$  gpm. This difference in yields over time could be due to heterogeneity of the aquifer, due to development related excavation, or an increase in impervious cover over the aquifer which may have altered the rate or locations of recharge. Wells constructed for Langford Municipality in 2001 and 2004 within the aquifer area obtained low water yields from the sand and gravel overburden and were constructed into bedrock prior to obtaining sufficient yields for irrigation purposes (Dave Newman, Langford Engineering, pers. comm. July 12, 2004). Slug testing of monitoring wells at Royal Roads found conductivity of the sand and gravel unit to range from  $1.2 \times 10^{-4}$  m/s to  $6.7 \times 10^{-6}$  m/s (Seacor Environmental Inc., 2003). If the aquifer is assumed to range from 1.2 m to 15 m in thickness (the difference between minimum and maximum well depth and min/max confining layer thickness), using conductivity values shown above, the transmissivity of the aquifer ranges from  $8.0 \times 10^{-6}$  m<sup>2</sup>/s to 0.18 m<sup>2</sup>/s.

What is the groundwater pumped from the aquifer used for?

Groundwater in the area is used mainly for domestic and irrigation purposes. Langford municipal irrigation wells are generally constructed into the underlying bedrock (Aquifer 606); and City of Colwood does not utilize wells for irrigation or municipal water supplies at present (David Reay, City Engineer, City of Colwood, pers. comm., July 14, 2004). Water may also be obtained from Langford Lake, Glen Lake, Florence Lake, Colwood Lake, Bilston Creek, the Goldstream River, and smaller perennial or ephemeral creeks located in the aquifer area. There are a total of 31 issued water licences for the above surface water bodies, for the purposed of irrigation, storage, land improvement and domestic use (Land and Water B.C. Inc., 2004).

What is the level of groundwater demand?

There is expected to be a low level of water demand. There are records of 34 wells completed into this aquifer (not including observation/monitoring wells at Royal Roads and Esquimalt Lagoon), corresponding to a density of 1 well/km<sup>2</sup>. Three wells located at Construction Aggregates Ltd. Metchosin gravel pit on Metchosin Rd. are abandoned or not in use. Nineteen wells on record are historical dug wells constructed in the 1940's to 1960's, which may be abandoned or infilled and no longer in use.

Describe the reliance on the aquifer for supply.

There is a low reliance upon the aquifer for supply. Although in parts of the aquifer area, including Sooke and Metchosin, rural residents may have a limited opportunity to connect to a municipal water source, many of the contemporary wells in these areas are constructed into

volcanic bedrock. Water for irrigation and domestic purposes may also be obtained from the surface water bodies listed above.

Are there any known water use conflicts?

There are no water use conflicts reported for the aquifer.

Describe the groundwater flow direction(s).

Groundwater is expected to flow from high elevation recharge areas to discharge areas at lower elevations. In the area of the aquifer extending southeast from Langford and Glen Lakes groundwater is expected to flow southeast toward the coast at Esquimalt Lagoon, as suggested in a hydrologic assessment of the Royal Roads property and groundwater monitoring in the suburban area to southwest of Esquimalt Lagoon (Seacor Environmental Ltd., 1001; Payne Engineering Geology Ltd., 1997). Above Langford Lake, groundwater flow may be northward, towards Goldstream River; however the data is insufficient to confirm groundwater flow direction at this time.

Describe the source(s) of recharge to the aquifer.

The source of aquifer recharge is thought to be from infiltration and runoff of precipitation in upland regions including the slopes of Skirt Mountain, Mount Wells, Centre Mountain, Braemar Heights and Triangular Hill, from direct precipitation over the aquifer area, or locally from wetland, stream and river infiltration. Local tributaries and wetlands are also expected to be a source of aquifer discharge.

How deep is the water table or the aquifer?

For wells presently included in the WLAP database, the arithmetic mean depth to water is 10 m (34 ft), the geometric mean depth to water is 5.8 m (19 ft) and the median depth to water is 5.9 m (20 ft), with a range from 1.5 to 29 m (5 to 94 ft). These values may not be representative as they were calculated using information available from 10 wells (29% of wells in the aquifer). City of Colwood monitoring wells southwest of Esquimalt Lagoon indicate a shallow water table in this area, with an upward hydraulic gradient, and artesian properties noted in some wells (Payne Engineering, 1996). One observation well is artesian, capped and the changes in pressure monitored monthly; five observation wells have water levels <1.0 m from the surface year-round, based on water level monitoring from 1997 to 2003 (David Reay, City Engineer, City of Colwood, pers. comm., July 2003).

The arithmetic mean well depth is 13 m (43 ft), the geometric mean well depth is 7.2 m (23 ft) and the median well depth is 4.3 m (14 ft). The minimum well depth is 1.8 m (6.0 ft), and the maximum well depth is 55 m (179 ft). Depth to bedrock varies from 2.4 m (7.9 ft) to > 55 m (180 ft), based on available well records.

Is the aquifer vulnerable to human activities at the land surface? If so, why?

The aquifer is considered moderately vulnerable to contamination from human activities at the surface. Well records indicated confinement is provided by clay, till, silt or combined clay and till, observed in 53% of the well logs. A clay confining layer is observed in 11 wells (32%), till is observed in 2 wells, combined clay, silt and till are observed in 5 wells. The overburden type is undetermined for 5 wells (15%) and there is no confinement observed in 11 wells (32%). The arithmetic mean, geometric mean and median confining layer thickness are 10 m, 4.8 and 5.2 m respectively (36, 18, and 19 ft); additionally, the confining layer thickness ranges from 0.61 to 40 m (2.0 to 130 ft). These sediments are thought to be Victoria clay (a glaciomarine silt and clay unit) and Capilano post-glacial sediments deposited at the end of the Fraser Glaciation (c. 13,000 to 5000 y BP) (Blyth and Rutter, 1993a). The surficial geology map also describes the majority of the aquifer area, including around Langford and Glen Lakes, as being overlain by a blanket (> 1 m thick) of glacial diamicton; marine clay overlies the aquifer closer to the coast at Esquimalt Lagoon; and in the Sooke/Dewdney Flats area, glaciofluvial sands and gravels are confined by glaciolacustrine clay and silt (Blythe and Rutter, 1993a and 1993b). The quaternary geology map confirms the existence of thicker marine clay overburden in the Esquimalt Lagoon area (Monahan and Levson, 2000). Present and historical development in the area may increase the aquifer's intrinsic vulnerability, by reducing the thickness of confining overburden and exposing the unconsolidated unit to potential direct introduction of contaminants at the surface.

Vulnerability indices such as the Aquifer Vulnerability Index (Van Stempvoort, et al., 1993) or DRASTIC (Aller, et al., 1987) were not used to evaluate individual well or aquifer vulnerability at this time.

Are there any documented water quantity concerns?

There are no documented concerns regarding water quantity.

Are there any documented water quality concerns that are health-related?

Light extractable petroleum hydrocarbon (LEPH) and polycyclic aromatic hydrocarbon (PAH) contamination of groundwater has been observed in the area surrounding a former underground fuel storage tank at Royal Roads University (Levelton Engineering Ltd., 1999; Levelton Engineering Ltd., 2001). Additionally, the shallow ground water table in the residential area southwest of Esquimalt Lagoon has contributed to incidences of septic system waste surfacing and high faecal coliform counts in storm-water runoff (Payne Engineering Ltd., 1996). There is no indication that localized contamination of the aquifer has affected domestic wells, and there are no documented health-related water quality concerns reported in Water Protection Section files.

Observation Wells

There is one inactive WLAP observation well constructed in the aquifer. There are seven observation wells west of Esquimalt Lagoon, in the area of Goldfinch Rd., Heatherbell Rd., Seafield Rd. and Portsmouth Dr., constructed and monitored by the City of Colwood

since August 1997 to monitor groundwater depth and quality (David Reay, City Engineer, City of Colwood, pers.comm., July 2003; Payne Engineering, 1997). There are an additional twenty-two 50 mm diameter monitoring wells at Royal Roads constructed by Thurber Engineering and Seacor Engineering in 1999, 2002 and 2003 (Seacor Engineering Ltd., 2003).

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### **Aquifer Classification Summary for Colwood Delta Aquifer (682)**

#### **Classification**

|                             |              |
|-----------------------------|--------------|
| Level of development (use): | III – Low    |
| Degree of vulnerability:    | B – Moderate |
| <b>Classification</b>       | <b>IIIB</b>  |

#### **Ranking Value**

|                                                      |                          |
|------------------------------------------------------|--------------------------|
| Productivity:                                        | 2 – Moderate             |
| Vulnerability:                                       | 2 – Moderate             |
| Size:                                                | 2 – 5-25 km <sup>2</sup> |
| Demand:                                              | 1 – Low                  |
| Type of Groundwater Use:                             | 3 – Multiple use         |
| Documented Quantity Concerns:                        | 0 – None reported        |
| Documented Quality Concerns Related to Human Health: | 1 – Isolated             |
| <b>Rank</b>                                          | <b>11</b>                |