Introduction
A detailed review of available hydrogeological reports was undertaken to assess the regional and local hydrogeology of the Lynden area in the process to identify suitable locations for development of additional groundwater sources. Review highlights are presented in this Technical Memorandum in part to address concerns raised at the public information centre (PIC) relating to site selection and any interference with local wells for the existing Lynden well and the proposed backup well. The review considered the following:

- Geology and Hydrogeology of the Lynden Area
- Existing Lynden Well
- Potential areas for backup supply

Geology and Hydrogeology of the Lynden Area
The Lynden area is on a gently rolling sand plain that slopes generally towards the Grand River to the southwest. The surface deposits in the area consist of fine sandy material that extends to shallow depths of approximately 7-8m below ground surface. This sand has been used as a shallow water supply for private dug wells. Below this sand unit is a thick layer of clay and silt that is up to 50m in thickness in the Lynden area. This layer acts as an aquitard, preventing the downward movement of water from surface sources such as precipitation. The clay layer is known to have isolated pockets of sandy material, which have also been used for domestic water supply. Beneath the clay layer is a sand and gravel aquifer that lies atop bedrock. This sand and gravel unit is thick in the areas to the south and east of Lynden and discontinuous elsewhere. To the east of Lynden along Governor’s Road, the aquifer consists of more gravel than sand. Gravel aquifers are generally better sources of groundwater supplies than sand aquifers. The deep aquifer is considered to be confined and is generally isolated from the surface aquifer because of the thick layer of clay and silt between the two aquifers.

The bedrock in the Lynden area is composed of dolostones of the Guelph formation. The bedrock is used as an aquifer in this area, but is mostly suitable only for domestic wells. The bedrock is known to contain hydrogen sulphide, which produces an odour in the groundwater. To the south and east of Lynden, an erosional feature cuts into the bedrock surface. This feature is mapped as the Dundas buried valley. This valley is part of the Dundas valley extending to the east towards Lake Ontario. The valley is filled with thick layers of sediment, the bottom of which
is suspected to contain sand and gravel deposits, with the potential to be used for municipal water supply in the future. The deepest part of the buried valley lies under Copetown, but tributaries to this valley have been found to extend to the south and east of Lynden.

**Existing Lynden Well**

A detailed groundwater exploration was conducted to find a suitable location for a well for Lynden (Morrison and Beatty, 1978). As part of the study, existing water well records were used to find possible locations for a well. The well records were used to develop geological cross-sections (Figure 1 - Morrison and Beatty, 1978) along the main roads in the area. The cross-sections were used to identify areas where potential aquifers were thick and continuous. The well records showed a thick sand aquifer to the south of Lynden, and a thick gravel aquifer to the east. Since gravel aquifers tend to be better groundwater sources, a well was drilled to the east of Lynden and a pumping test was conducted by Morrison and Beatty in 1984-85. A 24-hour pumping test was conducted at a pumping rate of 19 L/s (250 igpm). The drawdown results are shown in Figure 2 (Morrison and Beatty, 1985). The pumping test showed potential impacts to existing deep wells in the area for a pumping rate of 19 L/s (250 igpm). The well was estimated to have a safe perennial yield of 6.4 L/s (85 igpm) with a maximum pumping rate of 7.6 L/s (100 igpm). As such, it was recommended that the pumping rate be limited to 3.78 L/s (50 igpm), which was the current water requirement at the time, and the maximum pumping level not decline more than 3m (10 feet) below the baseline water level.

A second pumping test was conducted in 1987 by Morrison and Beatty, on the well over a period of 13-days in response to concerns from the community. The test was conducted at the recommended pumping rate of 3.78 L/s, with monitoring of water levels in 20 private wells (shallow and deep). The locations of the wells that were monitored during the pumping test are shown in Figure 3 (Morrison Beatty Ltd., 1987). At the end of the test, less than a 3m drop in water levels in the deep wells was observed. The results of the pumping test are illustrated in Figure 4 and Figure 5 (Morrison Beatty Ltd., 1987). The shallow wells did not show a response to the pumping, implying a disconnect between the shallow and deep aquifer systems. Once the well was commissioned, no complaints regarding well interference have been received by the City.

A groundwater resource characterization and wellhead protection study was undertaken by Charlesworth and Associates and SNC Lavalin (2006) for the City of Hamilton. This study included a cross-section, which extended along Governor’s Road from north of Brantford in a straight line across to Lake Ontario (Figure 6). The section shows a deep drop-off of the bedrock surface under Copetown and between Big Creek and Spencer Creek. The drop in bedrock surface corresponds to a thickening of the sand and gravel deposits that fill the valley.

In 2006, a desktop hydrogeological study was conducted by XCG Ltd. to identify a suitable location for a backup for the existing municipal supply well for the Lynden RSA. As part of the site selection assessment cross-sections were created from MOE well data. Figure 7 (XCG, 2006) depicts the locations of the cross sections while Figure 8, Figure 9 and Figure 10 (XCG, 2006) show the three most relevant cross-sections. The cross-sections show that the gravel aquifer is discontinuous across the area, but is known to be thicker in the vicinity of the existing well.
More recently, additional detailed studies have been conducted by the Ontario Geological Survey (OGS), Earthfx and AquaResource Inc. to look closely at the buried valley in the Hamilton area. The existing Lynden well appears to be located above a tributary valley close to the edge of the existing bedrock valley (Figure 11).

Based on the studies conducted over the last 30 years, a clear understanding has been gained of the hydrogeological conditions in the Lynden Area. A summary of relevant studies is included in Table 1.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Report Purpose</th>
<th>Aquifer</th>
<th>Data Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morrison Beatty Ltd. 1978.</td>
<td>Groundwater Exploration</td>
<td>Sand and Gravel</td>
<td>MOE Water Well Database</td>
</tr>
<tr>
<td>Unknown, 1981</td>
<td>Groundwater Exploration</td>
<td>Bedrock</td>
<td>Unknown</td>
</tr>
<tr>
<td>Morrison Beatty Ltd. 1985</td>
<td>Testing of Drilled Well</td>
<td>Gravel</td>
<td>MOE Water Well Database</td>
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<td>Gravel</td>
<td>MOE Water Well Database</td>
</tr>
<tr>
<td>SNC Lavalin and Charlesworth and Associates, 2006.</td>
<td>Regional Hydrogeological Study</td>
<td>Gravel</td>
<td>Drilling, Pumping Test</td>
</tr>
<tr>
<td>XCG Consultants Ltd., 2006.</td>
<td>Groundwater Exploration</td>
<td>Gravel</td>
<td>MOE Water Well Database</td>
</tr>
<tr>
<td>AquaResource, 2007</td>
<td>Buried Valley Exploration</td>
<td>N/A</td>
<td>MOE Water Well Database</td>
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<tr>
<td>GENIVAR, 2008</td>
<td>Groundwater Exploration</td>
<td>Gravel</td>
<td>Existing Reports</td>
</tr>
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</table>

These studies have identified a deep gravel aquifer to the east of Lynden, and that there is a disconnect between the shallow and deep aquifers because of a thick layer of clay and silt between them. This is confirmed by monitoring data in a shallow monitoring well next to the Lynden supply well, which shows no water level fluctuations related to pumping.

**Potential Areas for Backup Supply**

A backup well has been recommended for the Lynden system to provide back-up and increased security for the community water supply, to be used only when the existing well is not functioning. As such, an Environmental Assessment (EA) was initiated to find a location for a new well. A hydrogeological investigation was conducted using existing water well data and the historical groundwater reports cited above to find a suitable aquifer. The study identified a number of screening criteria that were used to pick the most suitable location for a new well. After a preferred area had been selected, further investigation focused on a City-owned parcel of land about 500m east of the existing well. When screening criteria were applied, the City-owned site proved to be the best location at which to further investigate the establishment of a backup well.
Summary of Hydrogeological Conditions in the Lynden Area

Figure 1
Figure 2

**Drawdown in Test Well**

- **as = 2.8 ft**
- **T = 23,600 gpd/ft**
- **as = 5.6 ft**
- **as = 11.2 ft**

**TABLE:**

<table>
<thead>
<tr>
<th>WELL NO.:</th>
<th>TW 1</th>
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<tbody>
<tr>
<td>PUMPING RATE:</td>
<td>250 gpm (900 L/s)</td>
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<tr>
<td>STATIC LEVEL:</td>
<td>35 ft bgl (10.7 m)</td>
</tr>
<tr>
<td>TEST DATE:</td>
<td>Dec. 20-21, 1984</td>
</tr>
</tbody>
</table>

**REGIONAL MUNICIPALITY OF:**

HAMILTON-WENTWORTH

**PROJECT NO.:** 59-841

**VILLAGE OF LYNDEN**

**DATE:** MAY 1985

**CONTRACT:**

monihan beatty limited
consulting engineers and hydrogeologists
Figure 3
Figure 4

Drawdown Plot - Lynden Test Well

PUMPING RATE = 50 gpm

PUMPED WELL: TEST WELL
REGIONAL MUNICIPALITY OF
STATIC LEVEL: 32.12 ft. b.m.p.
HAMILTON-WENTWORTH
TEST DATE: APRIL 19 - MAY 2, 1986

AQUIFER PERFORMANCE TEST
Figure 5

Drawdown Plot - Lynden Test
Well - Log Scale

- Drawdown vs Elapsed Time
- Aquifer Performance Test

WELL NO. TEST WELL
STATIC LEVEL 52.12 ft.
TEST DATE APRIL 19 - MAY 2, 1986

Regional Municipality of Hamilton-Wentworth

Marlton Beatty Limited
Consulting Engineers and Hydrogeologists
Figure 9

Figure 10
Figure 11