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Staff Report PW2018–049

Title of Report: Source Water Protection Updated Technical Study for Dundalk Well D5

Department: Environmental Services - Water

Council Date: April 18, 2018

Council Recommendation:

Be it resolved that Council receive Staff Report PW2018-049 for information; and

That Council endorse the Source Water Protection updated technical study for Dundalk Well D5 that will be included in the draft updated Grand River Watershed Assessment Report.

Background:

With the development of Dundalk Well D5 the Township of Southgate worked with the Grand River Conservation Authority (GRCA), which secured funding to tender for the study report of the Well Head Protection Area (WHPA) delineation and vulnerability scoring by Golder Associates Ltd. (Attachment # 1)

Staff Comments:

Risk Management Official (RMO), Jim Ellis attended the Lake Erie Region Source Protection Committee (SPC) meeting on April 5, 2018 at the Grand River Conservation Authority in Cambridge. The SPC approved Report No.SPC-18-04-06 incorporating the Dundalk Water Quality WHPA Update Technical Study into the Draft Updated Grand River Watershed Assessment Report. (Attachment #2)

The Ministry of Environment and Climate Change has established a new regulation under the Safe Drinking Water Act to ensure sources of drinking water for new or expanding municipal drinking water systems are protected before treated water is provided to the public taking effect on July 1, 2018. (Attachment #3)

The Council resolution for PW 2018-046 in endorsing the Source Water Protection updated technical study for Dundalk Well D5 that will be included in the draft updated Grand River Watershed Assessment Report will fulfill and support the proposed requirement.

Financial Impact or Long Term Implications:

There are no financial implications to the recommendation of this report.

Communications & Community Action Plan Impact:

This report has been written and presented to Council to communicate this information to the public and for Council's approval.

Goal 3: Environmental Conservation
Southgate Goal #3.1 – Southgate will take the actions for which it is responsible, and support the actions of other agencies, to protect identified sources of drinking water.

Concluding Comments:

Staff recommends that Council receive Staff Report PW2018-049 for information; and that Council endorse the Source Water Protection updated technical study for Dundalk Well D5 that will be included in the draft updated Grand River Watershed Assessment Report.

Respectfully Submitted,

Dept Head: Original signed by

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Note:
The contents of this report is provided in good faith and is based on information deemed to be accurate and in compliance with all applicable legislation and regulations at the time of publication to the best of our knowledge.

Attachment # 1 WHPA delineation and vulnerability scoring by Golder Associates Ltd.

Attachment #2 Lake Erie Region Source Protection Committee Report No.SPC-18-04-06

Attachment #3 Clean Water Act, 2006 General Regulation (O.Reg.287/07) Amendment and New Regulation under the Safe Drinking Water Act, 2002 Question and Answers EBR Decision Notices: April 5, 2018

January 2018

REPORT

VILLAGE OF DUNDALK

WHPA Delineation and Vulnerability Scoring

Submitted to:
Grand River Conservation Authority
400 Clyde Road, PO Box 729
Cambridge, Ontario
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Report Number: 1786493

Distribution:

1 Electronic Copy - GRCA
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Golder Associates

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) is pleased to present the Grand River Conservation Authority (GRCA) with this report detailing capture zone updates for the Dundalk municipal wells. The Dundalk municipal system is located within the Township of Southgate near the northern limits of the Grand River watershed (Figure A1). The residents of Dundalk are reliant on groundwater to meet their municipal water supply demands.

The objectives of the current assessment include updating the Dundalk groundwater flow model (Golder, 2010a) based on the most recent hydrogeological data and new municipal well, and thereafter using the refined model to delineate capture zones for the Dundalk municipal wells. The work also included a vulnerability assessment. The modelled capture zones form the basis of updated Wellhead Protection Areas (WHPAs), which in turn will guide a groundwater threats assessment (to be completed under a separate project).

1.1 Background

The Village of Dundalk is located in the Township of Southgate, County of Grey and is situated within the Grand River Watershed, which is part of the Lake Erie Source Protection Region. Dundalk relies on groundwater as a municipal water supply source. The municipal water supply system for Dundalk consists of two bedrock wells referred to as D3 and D4. Well D3 was drilled in 1975 and is located in the south end of Dundalk. Well D4 was drilled in 2002 to replace wells D1 and D2 and is located northeast of the Village. The wells range in depth from approximately 87 metres (m) below ground surface (bgs) at D3 to 101 m bgs at D4.

The Township of Southgate has identified that the community of Dundalk's maximum day water taking demand over the next 10 years is expected to increase to 2,250,000 L/d. The current permit to take water (PTTW No. 2845-96VQWL), under which wells D3 and D4 operate, allows for a maximum daily taking of 2,817,360 L/d. The PTTW allows for 1,180,800 L/d from D3 and 1,636,560 L/d from D4. Based on the existing permitted rates, the maximum day demand can be met using both wells, but if one well is taken out of service, the maximum day demand cannot be met. As such, a third well of similar capacity was needed to ensure maximum day water takings can be met. The work will be required to go through a Class EA process.

An exploratory drilling and testing program was initiated to address the need for a third municipal supply well. A new well referred to as D5 was constructed on the east side of Dundalk between wells D3 and D4. The well was constructed in 2016 to a depth of approximately 96 m bgs. A long-term pumping test was conducted at the well in January 2017. The new well will provide an additional groundwater source and will become part of the Dundalk municipal water supply. A summary of the hydrogeological investigation is included in a report by Groundwater Science Corp. (2017).

Beginning in the early 2000's, projects have been undertaken within the County of Grey to understand, manage and protect groundwater resources. As part of those projects, a numerical groundwater flow model was developed and updated over the years. The following provides a chronological history of the Dundalk groundwater modelling:

- **2003**: Groundwater modelling for the Township of Southgate was first undertaken by Waterloo Hydrogeologic Inc. (WHI) in 2003 as a part of a larger groundwater study in Grey and Bruce Counties (WHI, 2003). A three-dimensional MODFLOW model was developed, calibrated, and used to delineate the WHPA boundary for Dundalk municipal wells (then D1, D2, and D3).
- **2007**: The groundwater model was updated by WHI, Blackport Hydrogeology and Triton Engineering Services in 2007 to include the decommissioning of wells D1 and D2 and the installation of well D4 in 2007

as well as extending the model to the headwaters of the Grand River north and east of Dundalk (Triton Engineering et al., 2007).

- **2009/2010**: Golder undertook a review of the 2007 model and refined the hydrogeological conceptualization based on information collected since the completion of the previous modelling. Following these refinements, the groundwater model was used to update the capture zones (D3 and D4) for the Dundalk municipal supply wells (Golder, 2010a).

The need to incorporate the new Well D5 is the primary reason for updating the model and performing the current work.

1.2 Scope of Work

The following tasks were completed as part of this assessment:

- Update the modelled bedrock surface based on geologic picks from Well D5 and more recent (post 2010) entries to the Ministry of the Environment and Climate Change (MOECC) Water Well Information System (WWIS) database (MOECC, 2017);
- Review the MOECC PTTW database to identify any large water takings within the model domain (note that no additional large water takings were identified within the model domain);
- Calibrate the model in transient mode to Well D5 pumping test data;
- Calibrate the model in steady-state mode to WWIS static groundwater elevations and static water levels from the Well D5 pumping test;
- Delineate time-of-travel related capture zones for wells D3, D4 and D5 with forecast well pumping rates;
- Review the existing intrinsic vulnerability assessment and preferential pathways to update the vulnerability scoring;
- Conduct an uncertainty analysis; and
- Reporting and metadata delivery.

Section 2 of this report describes the conceptual hydrogeological model, Section 3 describes the construction of the updated Dundalk MODFLOW groundwater model, and Section 4 presents the time-of-travel capture zones developed for Wells D3 D4, and D5. Section 5 includes the vulnerability assessment and Section 6 provides a rating of the uncertainty of the WHPAs. A summary is provided in Section 7 and the limitations of the modelling are provided in Section 8.

2.0 CONCEPTUAL HYDROGEOLOGICAL MODEL

The original conceptual hydrogeologic model for the Dundalk area was described in the Grey and Bruce Groundwater Studies (WHI, 2003), and was refined through subsequent updates to the groundwater flow model completed in 2007 and 2010 (Triton, 2007; and Golder, 2010a). Data collected subsequent to the 2010 assessment (including aquifer testing and WWIS information) was used as part of the current work to refine the conceptual model further. The sections below summarize the current conceptual model, with changes subsequent to the 2010 assessment specified.

2.1 Topography and Drainage

Figure A2 displays the topography and drainage for the study area. Ground elevation ranges from a topographic high of 535 masl in the eastern portion of the model domain to a low of about 475 masl along the western model boundary. Surface drainage within the south-eastern portion of the model boundary is controlled by the headwater creeks and associated tributaries to the Grand River. Surface drainage in the remaining model area is controlled by numerous tributaries that drain towards the north-east (towards the Saugeen River, which lies outside the model domain).

2.2 Geology

2.2.1 Surficial Geology

The surficial geology of the Dundalk area consists mainly of drumlinized till plains, as defined by Chapman and Putnam (1984). Locally this is characterized as Elma Till (consisting of stony sandy silt to silt) and Catfish Creek Till (consisting of clayey silt and gravel). Isolated deposits of glaciolacustrine, glaciofluvial ice-contact, and glaciofluvial outwash materials are also found towards the northwest portions of the study area.

2.2.2 Bedrock Geology

Silurian dolostones, which are layered sedimentary rocks formed in a shallow ocean, are found underlying the overburden in the Dundalk area. The Ontario Geological Survey (OGS) has mapped the Silurian carbonate strata along the Niagara Escarpment region and revised the stratigraphic nomenclature. The bedrock units under the revised OGS nomenclature include the Guelph, Eramosa, Goat Island and Gasport Formations, which are part of the Lockport Group underlying the Dundalk area. The bedrock exhibits a gentle regional dip to the west. There is limited high quality geological bedrock borehole information in the Dundalk area and detailed three-dimensional mapping of the geologic formations is constrained by the available data.

Based on the available oil and gas borehole records, the uppermost bedrock formations (Guelph through Gasport (formerly Amabel Formation)) is estimated to be 88 m thick based on the oil and gas borehole log H000015 (located approximately 4 km southeast of Dundalk). Municipal wells are completed within this portion of the bedrock sequence and the Guelph to Gasport Formations form the active municipal groundwater system. The underlying formations (Clinton and Cataract Groups) act as the base of the active municipal groundwater system in this area.

2.2.3 Bedrock Surface and Overburden Thickness

Overburden thickness in the Dundalk area was estimated based on the available borehole records from the WWIS database (as of July 2017), logs from the municipal well drilling, and six oil and gas wells. The WWIS records were screened to exclude those that had poor location accuracy (i.e., only wells with a location accuracy better than 300 m were included). There was considerable variability in the quality of each well log and the descriptions therein; and professional judgment was applied in the interpretation of the reliability of the information. As such, not all MOECC well logs were utilized as geological picks; a total of 32 were removed from 686 data points. The bedrock surface was subsequently checked for consistency with "push down" points (i.e., boreholes which terminate within the overburden deposits and therefore provide knowledge on the maximum elevation of the bedrock surface) as well as against the ground surface.

The interpreted bedrock topography and overburden thickness maps are provided on Figures A3 and A4, respectively. As shown on the figures, the bedrock surface is generally highest in the east and slopes towards the west across the study area. This corresponded to interpreted overburden thicknesses ranging from approximately 5 m in the eastern portion of the study area to over 40 m in the southwestern portion. It should be noted that the interpreted bedrock elevation and overburden thickness maps have been updated based on data collected subsequent to the 2010 assessment. However, the new data resulted in only minor and localized changes being made. In the area of the well D5 the revised bedrock surface is approximately 1.5 m higher than the previous interpretation.

2.3 Hydrostratigraphy

The conceptual hydrostratigraphy includes the following units, from surface downwards (Figure A5):

- Overburden (the overburden units defined in Section 2.2.1 were each considered as independent hydrostratigraphic units);
- Contact zone (bedrock) aquifer;
- Shallow Guelph-Gasport Aquifer;
- Intermediate Guelph-Gasport Aquifer;
- Deep Guelph-Gasport Aquifer, and
- Bedrock below the Guelph-Gasport Aquifer (Clinton and Cataract Group Formations).

The upper surface of the till units was assumed to be impacted by weathering, and was therefore assumed to have a higher hydraulic conductivity in the upper portion compared to the lower portion. The previous testing and modelling identified these units as an aquitard. Underlying the till units, a 5 m thick continuous weathered bedrock zone (i.e., a "contact aquifer zone") was assumed.

The previous interpretation of the bedrock hydrostratigraphy assumed one unit for the Guelph-Gasport aquifer. As a result of reviewing borehole data and hydraulic response testing data collected during the drilling and testing of municipal well D5, in combination with numerical modelling of the well D5 pumping test (described in Section 3.9), it was determined that the hydraulic properties of the bedrock aquifer likely vary with depth and the conceptual model should be revised to include the new hydrostratigraphic interpretation. The investigation at well D5 (Groundwater Science Corp., 2017) indicated water bearing zones reported at depths of 57.9 and 87.5 m with the majority of the water obtained by the municipal wells interpreted to come from the deep aquifer zone. The hydrogeologic investigation at well D4 (Anderson GeoLogic, 2002) indicates that water bearing zones were encountered at 38.1, 47.2, 65.5, 79.2, 91.4 and 94.5 m depths, with the uppermost zones being relatively minor and the majority of water appearing to be available from the 91.4 and 94.5 m depths. The water well record for well D3 indicates water was found at 34.7 to 44.2 m and from 61.0 to 86.9 m. It appears that the majority of the water at the three municipal wells comes from the lower part of the wells or middle part of the bedrock aquifer. The upper part of the bedrock aquifer does not produce as much water as the intermediate zone and there is no information on the hydraulic properties of the lower zone. As such, the current interpretation divides the portion of the Guelph-Gasport aquifer below the contact aquifer zone into three hydrostratigraphic units: a shallow zone of lower permeability that incorporates the top 22 m of the aquifer; an intermediate zone of higher permeability, with a thickness of 33 m, and; a deep zone of lower permeability, with a thickness of 28 m. The intermediate zone corresponds to the higher producing zones observed in the municipal wells during the testing.

2.4 Aquifer Transmissivity

Transmissivity estimates of the Guelph-Gasport aquifer were available from interpretation of hydraulic response testing data. Results of a 72 hour pumping test completed on Dundalk Well D4 (completed in the Guelph-Gasport aquifer) showed a range of transmissivity between 7.6×10^{-4} m^2/s and 1.3×10^{-3} m^2/s (Anderson, 2002), which translates to a hydraulic conductivity range between approximately 1×10^{-5} m/s and 2×10^{-5} m/s. Further, a five day pumping test was completed on Dundalk Well D5, which showed a range of transmissivity between 1.2×10^{-3} m^2/s to 7.3×10^{-3} m^2/s (Groundwater Science Corp., 2017), which translates to a hydraulic conductivity range between approximately 2×10^{-5} m/s and 1×10^{-4} m/s. Additional details on the D5 pumping test are provided in Section 3.9.

2.5 Groundwater Flow

A groundwater elevation map for the bedrock was developed from well water levels in the MOE WWIS and is illustrated on Figure A6. In general, groundwater elevations in the bedrock are highest along the northeast boundary of the groundwater model where an inferred groundwater divide occurs, and decrease towards the west and south. Although new (post-2010) data were used to generate the groundwater elevation map, the general gradients and groundwater flow directions are the same as the 2010 interpretation. The data used to develop the groundwater elevation map on Figure A6 provide the basis for steady-state calibration of the groundwater model (discussed in Section 3.9 below).

3.0 GROUNDWATER MODEL CONSTRUCTION AND CALIBRATION

As noted earlier, the numerical (MODFLOW) model developed as a part of the 2003 Grey and Bruce Groundwater Studies (and its subsequent updates in 2007 and 2010), was used as the starting point for the construction of the current model. A summary of the overall parameterization of the model as well as the updates completed in building the current Dundalk MODFLOW groundwater model are provided in the sections below.

3.1 Modelling Approach

The objective of the groundwater modelling for the Dundalk municipal water supply system was the determination of time-related capture zones for its municipal groundwater supply wells. The time-related capture zones of interest include the: 0 to 2 year time of travel (ToT); 2 to 5 year ToT; and the 5 to 25 year ToT. The Ontario Ministry of Environment and Climate Change "Technical Rules: Assessment Report" (MOE, 2009) identifies the aforementioned capture zones as follows:

- 2 Year Time of Travel: Wellhead Protection Area Zone B.
- 5 Year Time of Travel: Wellhead Protection Area Zone C.
- 25 Year Time of Travel: Wellhead Protection Area Zone D.

(Note: in addition to the above, the guidance document also identifies a Pathogen Security/Prohibition Zone (Zone A), defined as the zone within a 100 m radius around the well).

The 2010 3D numerical (MODFLOW) groundwater model for the Dundalk area was updated according to the revisions to the conceptual hydrogeological model noted above, re-calibrated to recent (post 2010) water level and aquifer test data and predictive simulations were completed using forecasted pumping rates to delineate the capture zones. This involved using MODPATH (a companion code to MODFLOW) to release groundwater particles at the pumping wells, tracking their paths backwards through the groundwater flow field, and projecting their pathlines on a horizontal plain to represent a two-dimensional (2D) projection of the capture zone. This approach is consistent with the previous assessment.

3.2 Code Selection and Description

MODFLOW-NWT (Niswonger et al, 2011) and MODPATH were used to estimate the time-related capture zones. MODFLOW is a multi-purpose three dimensional groundwater flow code developed by the United States Geological Survey. It is modular in nature and uses the finite difference formulation of the groundwater flow equation in its solution. MODFLOW has been recognized as an industry standard for general purpose groundwater flow modelling and has gained wide acceptance from academia, consultants and regulatory agencies worldwide. Visual MODFLOW® (Version 4.6.0.168) was used as the numeric flow engine for the simulations presented in this report. MODPATH (Pollock, 1989), a companion code to MODFLOW, was used to complete the particle tracking analyses necessary for the capture zone delineation.

3.3 General Modelling Assumptions

The use of the MODFLOW/MODPATH groundwater model infers that the groundwater flow system in the Dundalk area can be simulated as an "equivalent porous media" at the scale of the time-related capture zones under consideration (i.e., 0 to 2-year ToT; 2 to 5 year ToT; and 5 to 25-year ToT). Under this assumption, the rate of groundwater flow towards a pumping well occurs as a function of the hydraulic gradient, the hydraulic conductivity, and the porosity of the aquifer. Whereas groundwater flow in bedrock aquifers is controlled primarily by fracture flow, an equivalent porous media approach is commonly used to represent groundwater flow in these aquifer systems. This is considered reasonable provided the scale of the observation (i.e., in this case the extent of the capture zone) is much greater than the scale of the individual fractures, and consideration is given to the selection of a reasonable effective porosity. There is no direct estimate of the effective porosity for the bedrock aquifer in Dundalk; a value of 5 percent has been assumed which is consistent with typical values used in these calculations for other groundwater studies completed within the Province and used in the previous Dundalk models.

3.4 Grid Discretization

The model grid was discretized into a uniform 100 m cell size over the full extent of the model domain, except in the Dundalk area where the grid gradually transitions to an 8 m cell size in the vicinity of wells D3, D4 and D5. This resulted in a total of 261 rows and 247 columns. Vertically, the model was discretized into 15 numerical layers. The total number of grid cells in the updated Dundalk MODFLOW groundwater model is 967,005.

3.5 Model Layering

Seven hydrostratigraphic units were considered in this assessment (see Figure A5 and Section 2.3), which were numerically represented using a total of 15 grid layers within the model. From the surface down, the numerical layers were defined as follows:

- Layer 1: The uppermost layer is comprised of various overburden units (Figure A7-1), as defined by surficial mapping of the area (Chapman and Putnam, 1984), and extends 3 m down from the surface over the model domain. The top surface of this layer was defined by topography;
- Layer 2: A zone of weathering within the Elma Till unit (Figure A7-1), ranging in thickness from approximately 10 m to 15 m, that effectively increases the hydraulic conductivity of this units. Catfish Creek Till also comprises part of this layer, but was assumed to be weathered in the upper 3 m only;
- Layer 3: Non-weathered Catfish Creek and Elma Till units (Figure A7-1);
- Layer 4: The contact aquifer layer; a 5 m thick layer which parallels the bedrock surface and conceptually represents the weathered bedrock surface (Figure A7-2). The top of this layer was defined by the bedrock surface;
- Layers 5 – 14: The Guelph-Gasport aquifer, with a total thickness of approximately 83 m. As discussed in Section 2.3, this formation was subdivided into three units: a shallow zone of lower permeability that incorporates the top 22 m of the formation; an intermediate zone of higher permeability, with a thickness of 33 m, and; a deep zone of lower permeability, with a thickness of 28 m (Figure A7-2). Nine numerical layers were used to subdivide the three Guelph-Gasport aquifer units to improve resolution of vertical gradients; and
- Layer 15 was defined by a 28 m-thick bedrock unit of lower hydraulic conductivity, which represents the rock units present between the base of the Gasport and the top of the Ordovician Queenston Shale Formation (Figure A7-2). Regionally, this would include the Clinton and Cataract Group formations.

3.6 Groundwater Flow Boundaries

Flow boundaries (Figure A8) were identical to those used in the 2010 assessment. Drain boundaries were defined in the upper layer of the model based on GRCA watercourse mapping. This type of flow boundary is only capable of removing water from the groundwater model, which is considered representative of the general behaviour of those surface water features as groundwater discharge zones. The assigned drainage head was set at ground surface elevation.

In addition to the drain boundaries, constant head boundaries were specified at two locations along the southern and western most points of the model, as shown on Figure A8. These boundaries were developed based on the regional groundwater flow map prepared for the bedrock aquifer, which denotes groundwater flow across the model boundary at these locations.

Vertically, the model is bounded at its top by topography and at its bottom by the top of the Queenston Shale (which is assumed to act as a no-flow boundary).

3.7 Hydraulic Parameters

With the exception of the Guelph-Gasport aquifer, the hydraulic conductivities assigned to the model hydrostratigraphic units are identical to those in the 2010 model. The modelled hydraulic conductivity distributions for the overburden and bedrock units are shown on Figures A7-1 and A7-2. Hydrogeological properties of the various geological units were determined through model calibration. The calibrated hydraulic conductivity of the Intermediate Guelph-Gasport aquifer specified in the groundwater flow model was 1.5×10^{-5} m/s, which lies within the measured range (see Section 2.4). The shallow and deep portions of the Guelph-Gasport Aquifer was specified as 1x10^{-8} m/s. Specific details on model parameterization for each geologic unit are provided in Table 1A. The parameters used in the 2010 model are included in Table 1B for comparison.

3.8 Recharge

The recharge distribution applied in the updated model is shown on Figure A8. Recharge rates in the model were defined based on the surficial geology and topography, and ultimately finalized through the calibration process. These ranged from 35 mm/yr to 125 mm/yr. Compared to the previous model, recharge rates applied over the Catfish Creek till and upland portions of the weathered Elma till were reduced by 50 % to improve calibration.

3.9 Model Calibration

Model calibration involved two components. First, a transient simulation was completed where the model was configured to represent the five day pumping test at Well D5. Adjustments were made to model parameters until an acceptable match was achieved between the measured and simulated drawdown and recovery of groundwater levels at monitoring wells. A secondary steady-state simulation was completed where the updated model was used to compare simulated groundwater elevations to target groundwater elevations from WWIS data on a regional scale.

3.9.1 Transient Calibration

Table 2 provides the pumping rates from wells D3, D4, and D5 recorded throughout the pumping test period, and in the periods before and after the pumping test. In reality, pumping from the existing municipal supply wells (D3 and D4) cycled on and off repeatedly throughout the pumping test period, and this was simplified so that the average pumping volumes over the duration of each stage of the pumping test were represented in the model.

Throughout the pumping test groundwater elevations were monitored using pressure transducers installed in 4 monitoring wells. Changes in groundwater elevation (drawdown) at the 4 monitoring wells were calculated over the pumping and recovery period, and used as target values for the transient simulation. Details on the location and completion information for the observation wells are provided in Figure A9.

Table 2: Pumping Rates During Pumping Test of Well D5

Period	From	To	D3 (m^3/d)	D4 (m^3/d)	D5 (m^3/d)
Pre-test (3 days)	1/20/2017 12:15	1/23/2017 12:15	201	215	0
Stage 1 of Test	1/23/2017 12:15	1/25/2017 12:15	219	213	2,592
Stage 2 of Test	1/25/2017 12:15	1/26/2017 17:15	167	172	2,160
Stage 3 of Test	1/26/2017 17:15	1/28/2017 12:00	226	224	1,944
Post-test (3 days)	1/28/2017 12:00	1/31/2017 12:00	198	199	0

The model was configured as a 10 day transient simulation, beginning on January 23, 2017 at 12:15 pm. The initial condition for the transient simulation was based on a corresponding steady-state simulation configured with the pre-test period pumping rates wells at wells D3 and D4 (per Table 2).

As a part of the transient calibration adjustments were made to the model parameters in an iterative process until simulated groundwater elevations compared well to observed data. The following provides a summary of the specific changes made to the 2010 model so that an acceptable calibration was achieved:

- Whereas the 2010 model specified one hydraulic conductivity value ($2x10^{-5}$ m/s) for the full thickness of the Guelph-Gasport aquifer, the updated model subdivided this unit into three zones: a shallow zone of lower permeability (hydraulic conductivity of $1x10^{-8}$ m/s) that corresponds to the top 22 m of the formation; an intermediate zone of higher permeability (hydraulic conductivity of $1.5x10^{-5}$ m/s), with a thickness of 33 m, and; a deep zone of lower permeability (hydraulic conductivity of $1x10^{-8}$ m/s), with a thickness of 28 m.
- Recharge rates applied to the weathered Catfish Creek till (originally 100 mm/yr) and the Elma till in upland areas (originally 150 mm/yr) were reduced to 50 mm/yr and 75 mm/yr, respectively. These areas are illustrated on Figure A8.
- Storage parameters were not specified as a part of the 2010 groundwater flow modelling. These were estimated through the transient calibration, and are summarized in Table 1A.

Results of the transient calibration are presented on Figure A10-1 as a time series plot of measured and calculated drawdown. In general, the drawdown and recovery recorded at the observation wells is reproduced by the model. The short-term fluctuations in measured groundwater elevation shown on the plot were caused by cycling of the pumps in wells D3 and D4. As noted previously, average pumping rates for these wells over each stage of the test were specified in the model, and as such the short-term changes in water level were not reproduced.

For comparative purposes, the results of the transient simulation completed using the 2010 model parameterization are provided on Figure A10-2. The poor fit between measured and calculated drawdown shown on the plot highlights the justification for inclusion of a low hydraulic conductivity unit between the contact zone aquifer and the production zone aquifer. Without this feature an acceptable calibration to the D5 pumping test may have otherwise not been achievable.

3.9.2 Steady-State Calibration

Following completion of the transient calibration, the updated groundwater flow model was run as a steady-state simulation to verify its calibration on a regional scale by comparing target groundwater elevations (from the WWIS) to simulated values. Pumping rates specified at D3 and D4 for this simulation were based on the average groundwater extraction between 2006 and 2016 (266 m^3/d at D3 and 297 m^3/d at D4).

Figure A11 shows the simulated bedrock groundwater elevations following calibration of the updated model. The simulated groundwater elevations indicate the overall groundwater flow direction is to the west/southwest, which is consistent with the inferred bedrock groundwater contours shown on Figures A6 and A11.

Figure A11 also shows a calibration plot for the updated model with selected calibration statistics. Generally, the simulated groundwater levels compare reasonably well with the measured groundwater levels. The steady-state calibration simulation resulted in a residual mean error of 2.3 m, an absolute residual mean of 3.3 m, and a normalized RMS error of 7.6%. A total of 236 calibration points were used. The residuals are also included on Figure A11.

Following the steady-state and transient calibration process it was found that the model parameterization (hydraulic conductivity, recharge and storage values) and simulated flow pattern within the aquifer were in good agreement with site specific information. The calibrated model values therefore represent suitable estimates for use in developing the theoretical capture zones for the Dundalk municipal wells under forecast pumping rates.

4.0 CAPTURE ZONE DELINEATION

The capture zones for Dundalk wells D3, D4, and D5 were determined by running the model with four different scenarios to represent possible combinations of future pumping from the wells, as summarized in Table 3 below. Scenario 1 represents the "base case" where pumping is equally divided between the wells. Scenarios 2 through 4 were defined to address uncertainty in the future operation of the municipal water supply system, and represent alternative pumping configurations that use two wells in combination.

The pumping rates used to determine the WHPA are based on the allocated quantity of water. In each scenario, the allocated quantity of water or the total pumping rate was 1,344 m^3/d. This is based on an estimate of the 20-year forecast planned demand provided by Triton Engineering, which represents the existing average day demand over the past three years for 1,799 people (490 m^3/d), plus a committed demand over the next 10 years for 2,111 people (574 m^3/d) and a planned demand for the next 20 years for 1,028 people (280 m^3/d).

Table 3: Simulated Pumping Rates for Capture Zone Delineation Scenarios

Well	Forecast Pumping Rate (m^3/d)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
D3	448	672	672	0
D4	448	672	0	672
D5	448	0	672	672

Following completion of the forecast groundwater flow simulations MODPATH was used to release groundwater particles at the pumping wells and backward-track their path through the simulated flow field. Particle traces resulting from each of the four scenarios are combined and projected on a two-dimensional horizontal plane. The particle traces for Scenarios 1 through 4 are shown on Figures B1 through B4, respectively.

Delineation of WHPAs represents the foundation of a municipal groundwater protection strategy, as this is the area projected to land surface where groundwater can be captured by pumping at the municipal wells. In order to take into account the uncertainty of pumping, the particle tracks for the four scenarios were combined to develop one "composite" capture zone. Capture zones are defined by drawing an area that encompasses the combined particle traces for 2-year, 5-year, and 25-year travel times. It should be noted that the capture zones represent time of travel within the saturated zone of the aquifer to the well and do not account for travel time from ground surface down to the water table. The resulting time of travel capture zones for wells D3, D4, and D5 are provided on Figure 1.

Generally, the capture zones extend north-northeast from the village in the direction (upgradient) of local groundwater flow through the bedrock. The land use overlying most of the WHPA out to the 5 year time of travel is within the urban area of Dundalk.

A comparison of the new WHPAs to the previous WHPAs (Figure 2) indicates the new WHPAs are more "rounded" and extend further downgradient compared to the previous WHPAs. Some reasons for the differences in the WHPA shapes are described below. The overall pumping from the 2010 model to the new model increased from 854 m^3/d to 1,344 m^3/d or approximately 57% increase. The increase in pumping will require a larger area to capture the water. Pumping is also occurring from 3 wells in the new model compared to 2 wells in the 2010 model. This also requires a greater footprint from where the groundwater is captured. By adding a third pumping well and varying the pumping scenarios, the capture zones shift as the wells compete with each other to capture the volumes pumped. In addition, the model was revised based on a better understanding of the conceptual model, taking into account the results of the recent drilling and testing at municipal well D5. The new model provided a better calibration to the pumping test, providing a more realistic solution to actual field conditions. The change in the hydrostratigraphic interpretation will also cause some of the difference between the 2010 capture zones and the new capture zones.

5.0 VULNERABILITY ASSESSMENT AND SCORING

Surface and sub-surface contaminants may pose a risk to groundwater resources and can have long-lasting impacts that can impair water quality conditions. The intrinsic vulnerability of the aquifer refers to the level of protection provided by the geological materials overlying the aquifer and is independent of the potential contaminant. The vulnerability assessment and scoring involves assigning the intrinsic vulnerability of groundwater, identification of transport pathways that may increase the vulnerability, and assigning vulnerability scores within the WHPA. The work completed as part of this study is described below.

5.1 Vulnerability Assessment

The intrinsic vulnerability mapping of the aquifer in the Dundalk area was provided by the GRCA, which is an assessment dataset maintained by the Lake Erie Source Protection Region (LESPR). The assessment was conducted on a regional watershed scale and refined at a local wellhead scale. Based on the metadata description, the intrinsic vulnerability is dependent on a number of factors including: the geologic structure, the hydraulic character of the sediments, the vertical hydraulic gradient, and the hydraulic connection between the surficial recharge water and the aquifer of interest. Most of the regional intrinsic vulnerability work was completed by EarthFX Inc. in 2010 using the Surface to Aquifer Advective Time (SAAT) method. The intrinsic vulnerability was then refined by Golder (2010b) on a local scale, at which time there were no adjustments to the intrinsic vulnerability in Dundalk, which is mainly considered low. The GRCA has indicated that the intrinsic vulnerability was adjusted in the Township of Malancthon in 2012 by Harden Environmental (Harden). The intrinsic vulnerability was updated by Harden using the Aquifer Vulnerability Index (AVI) method. The area within most of WHPA-B and WHPA-C for D3 and D5 and the southwestern part of WHPA-D are assessed using the SAAT method while the remaining area is assessed with the AVI method. The most recent intrinsic vulnerability assessment is shown on Figure 3. As shown on Figure 3 most of the area within the WHPA is considered low vulnerability with some medium vulnerability in the eastern edge of the WHPA. The main difference resulting from the update in 2012 is a shift to the east of the low/medium vulnerability contact near the southeastern part of the WHPA and a shift to the west of the low/medium vulnerability contact near the northeastern part of the WHPA. All of these changes are outside of WHPA-C.

As part of this study, the well record for D5 and water well records after 2010 with good reliability codes were reviewed within the WHPA area to determine if the intrinsic vulnerability should be adjusted. A review of the water well records indicated three new wells in the southeastern part of the WHPA outside of WHPA-C. The new records indicate sand at surface, however the wells are less than 4.5 m deep. Based on surrounding well records and the conceptual understanding of the geology, it is interpreted that a till layer underlies the sand at surface. The overburden in this area is interpreted to be approximately 20 m thick. As such, the wells are too shallow and do not warrant any adjustment to the existing intrinsic vulnerability, which was kept as is.

5.2 Preferential Pathways

A preferential pathway, or transport pathway, is a pathway of anthropogenic origin that can increase the rate at which a contaminant at surface could reach the aquifer compared to the time it would take to reach the aquifer if the pathway was not present (i.e. these pathways can increase the vulnerability of the drinking water sources to contamination). The Technical Rules allow for an increase in the vulnerability where man-made transport pathways can decrease the time for contaminants to reach a water supply source. An inventory and analysis of potential preferential pathways within the WHPA was conducted as part of this study. Potential preferential pathways for review include existing wells or boreholes, unused or abandoned wells, pits, quarries and areas licensed for aggregate extraction, mines, construction activities such as underground parking garages and deep excavations, septic systems, storm water infiltration and soak-away pits, and municipal underground services.

The first step in completing the adjustments was to determine if the risk factor of the potential transport pathways is considered to be high or low. To determine the risk, the following was considered:

- Location of pathways – distance of pathway from municipal well;
- Hydrogeologic conditions – the depths of the potential transport pathways were compared to the depths of the municipal aquifer;
- Type and design of any transport pathways – the various types of transport pathways were reviewed to determine whether they provide a high risk to the municipal aquifer. Only transport pathways that provide an actual pathway to the municipal aquifer or significantly reduce the travel time to a municipal aquifer were considered high risk; and
- Cumulative impact of any transport pathways – there is insufficient technical basis for establishing an area of increased vulnerability based on a single pathway that is very small in comparison to the scale of the study area and the vulnerability mapping. As such, only areas where a number of transport pathways exist in close proximity to each other were considered for an increase in vulnerability in that area.

5.2.1 Preferential Pathways in Dundalk

Since the Technical Study (Golder, 2010c), potential preferential pathways remain the same and include the following:

- Private wells at rural homes and farms in the area used for water supplies;
- Abandoned wells that may exist at some of the rural residences (but not identified based on the work to date);
- Septic systems associated with rural homes and farms; and
- Buried utilities within the urban area.

5.2.2 Adjustments to Vulnerability to Account for Preferential Pathways

Our interpretation of the Technical Rules is that the vulnerability of the aquifer should only be increased to account for a preferential pathway where there is sufficient confidence in the available data to justify increasing the vulnerability. Due to the fact that most of the potential preferential pathways are shallow (excluding wells) compared to the thickness of the aquitard overlying the municipal aquifer (i.e., they do not breach the aquitard), the risk factor for potential preferential pathways was considered low and no changes to the vulnerability were made.

With respect to the private wells, or abandoned wells, there have been no confirmed well pathways, and as such, no increases to vulnerability due to the presence of private wells has been included. However, we feel the decommissioning of abandoned wells or unused wells is an important part of source protection and should be included under a stewardship program or funding through the Township. This is not only for the protection of municipal drinking water sources, but also the protection of the quality of the groundwater resource for all users.

5.3 Vulnerability Scoring and Mapping

The vulnerability scores were applied by overlying the existing vulnerability mapping and the WHPA zones and scoring the vulnerability from 2 (lowest vulnerability) to 10 (highest vulnerability) as per the Technical Rules. The vulnerability scoring was conducted for the composite WHPA (D3, D4 and D5). The scoring in WHPA-C for low vulnerability is different depending on the method used for calculating intrinsic vulnerability (i.e., SAAT scores a 2 while AVI scores a 4). Since the regional scale intrinsic vulnerability was established using the SAAT method, and previous studies were scored with the SAAT method, the scoring for this study was also completed using the scoring associated with the SAAT method. Within the WHPAs, the vulnerability of the aquifers was scored as follows:

Table 4: Wellhead Protection Area Vulnerability Scores - SAAT

Groundwater Vulnerability Category	Location Within a Well Head Protection Area			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
High	10	10	8	6
Medium	10	8	6	4
Low	10	6	2	2

The vulnerability scoring map is shown on Figure 4 and was prepared to provide an indication of the relative vulnerability of the aquifer within the WHPAs and will be used for the threat risk scoring procedure (not part of this study). WHPA-A (100 m radius zone) is categorized as a vulnerability of 10, WHPA-B (2-year time of travel capture zone) is categorized as a vulnerability of 6, WHPA-C (5-year time of travel capture zone) and most of WHPA-D (25-year time of travel capture zone) are categorized as a vulnerability of 2. This is reflective of the low permeable sediments overlying the bedrock aquifer. Parts of the eastern edge of WHPA-D score a 4 where the vulnerability is medium.

6.0 UNCERTAINTY ASSESSMENT

An uncertainty assessment associated with the development of WHPAs and vulnerability mapping is required in order to assess the level of confidence in the results and determine the need for additional data collection and/or analysis as part of future assessments. Uncertainty ratings within each WHPA are to be designated as either high or low and can vary within the zones of the WHPA. The following are some of the conditions where a low uncertainty rating would be considered as noted below:

- In areas where the density of the data is high, and there is a high level of confidence in the quality of the data;
- In areas where hydrogeological studies have been completed to confirm the regional scale mapping that has been completed; and
- Where a numerical model has been sufficiently calibrated to observe data that includes aquifer testing at the well location, and water level data across the capture zone footprint, and there is a high level of confidence in the representation of the flow system (and flow system boundaries) through local hydrogeological studies, or subsequent verification simulations.

Within the Technical Rules a specific outline to determine the uncertainty is not given but indications are provided that the following factors are to be considered in the analysis:

- The distribution, variability, quality and relevance of data used in the assessment;
- The ability of the methods and models used to accurately reflect the flow processes in the hydrogeological system;
- The quality assurance and quality control procedures applied;
- The extent and level of calibration and validation achieved for models used or calculations or general assessments completed; and
- The accuracy to which the groundwater vulnerability categories effectively assess the relative vulnerability of the underlying hydrogeological features.

It should be recognized that because the municipal supply wells are completed in the bedrock aquifer, there is a fair amount of uncertainty over the times of travel and the effective area of capture. In a general sense, there would be greater uncertainty for bedrock systems than overburden systems due to the assumptions with effective porosity.

For the Dundalk area, in addition to the regional studies that have been conducted, local hydrogeological studies have also been completed including aquifer testing at Well D4 and Well D5. Also, numerous water well records exist for private wells located within and around the WHPA. After filtering out lower quality well records (due to location accuracy, missing geology and anomalous geology), the remaining water well records were used to fill in the gaps of the detailed studies. The WHPAs were delineated using a numerical model that had been calibrated reasonably well with the field data as described previously.

The intrinsic vulnerability mapping was initially conducted at a watershed scale to provide a consistent mathematical approach to the vulnerability aspect of the scoring. For Dundalk, these results were further reviewed at a WHPA scale and changes applied to improve the results and reduce uncertainty in the vulnerability mapping. Further assessment was conducted using a different method that produced similar results in the area of the WHPA. The vulnerability scoring is based on both the WHPA delineation and the intrinsic vulnerability mapping and therefore the overall uncertainty is related to the combined uncertainty of these two tasks.

Efforts have been made to reduce the uncertainty in the hydrogeological mapping products, following the guidance outlined in the Technical Rules (as stated above). However, some missing information is as follows: there is no site specific information on the effective porosity of the bedrock; there are relatively few high quality monitoring wells within and surrounding the capture zone to confirm the local groundwater flow direction; and the influence on the nature of the fracturing and distribution of water bearing zones within the bedrock are not explicitly mapped. Notwithstanding the above, the vulnerability scoring reflects the best estimate of the actual conditions at the Dundalk wells, and managing activities using this as the basis for Source Protection programs would serve to reduce the risk (threat) of future contamination to these wells. The WHPAs, intrinsic vulnerability and resulting vulnerability scoring for Dundalk are therefore estimated to have a low uncertainty rating.

7.0 SUMMARY

As part of the updated source protection assessment for Dundalk, the WHPAs were updated to include the new Well D5, intrinsic vulnerability mapping was reviewed along with preferential pathways and vulnerability scoring was completed.

The numerical groundwater model was updated with information post 2010 and calibrated to steady state conditions and transient conditions during the pumping test. The updated model was used to develop a composite WHPA for Wells D3, D4 and D5 based on different pumping scenarios.

Potential preferential pathways were reviewed to determine if the vulnerability scoring should be adjusted. No changes were made to the vulnerability mapping for the municipal WHPAs in Dundalk due to potential preferential pathways. The vulnerability scoring maps generally indicate that the vulnerability decreases with distance away from the municipal wells due to the overall low intrinsic vulnerability. The vulnerability scoring will need to be updated if changes occur to the WHPA delineation or the vulnerability assessment.

The uncertainty associated with delineating the WHPAs, preparing the vulnerability mapping and assigning the vulnerability scoring is considered to be low.

The information collected and compiled as part of this study can be used to update the Source Water Protection Assessment Report.

8.0 LIMITATIONS

8.1 Use of Report and Contents

This report has been prepared for the exclusive use of the GRCA. The factual information, descriptions, interpretations, comments, recommendations and electronic files contained herein are specific to the project described in this report and do not apply to any other project or site. Under no circumstances may this information be used for any other purposes than those specified in the scope of work unless explicitly stipulated in the text of this report or formally authorized by Golder. This report must be read in its entirety as some sections could be falsely interpreted when taken individually or out-of-context. As well, the final version of this report and its content supersedes any other text, opinion or preliminary version produced by Golder.

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References to acts and regulations that may be contained in this report are informally provided on a technical basis. Since acts and regulations are subject to interpretation, Golder recommends GRCA to consult with legal counsel to obtain suitable advice.

8.2 General Groundwater Modelling Limitations

Hydrogeological investigations and groundwater modelling are dynamic and inexact sciences. They are dynamic in the sense that the state of any hydrological system is changing with time, and in the sense that the science is continually developing new techniques to evaluate these systems. They are inexact in the sense that groundwater systems are complicated beyond human capability to evaluate them comprehensively in detail, and we invariably do not have sufficient data to do so. A groundwater model uses the laws of science and mathematics to draw together the available data into a mathematical or computer-based representation of the essential features of an existing hydrogeological system. While the model itself obviously lacks the detailed reality of the existing hydrogeological system, the behaviour of a valid groundwater model reasonably approximates that of the real system. The validity and accuracy of the model depends on the amount of data available relative to the degree of complexity of the geologic formations, the site geochemistry, the fate and transport of the dissolved compounds, and on the quality and degree of accuracy of the data entered. Therefore, every groundwater model is a simplification of a reality and the model described in this report is not an exception.

The professional groundwater modelling services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practising under similar conditions, subject to the quality and quality of available data, the time limits and financial and physical constraints applicable to the services. Unless otherwise specified, the results of previous or simultaneous work provided by sources other than Golder and quoted and/or used herein are considered as having been obtained according to recognised and accepted professional rules and practices, and therefore deemed valid. This model provides a predictive scientific tool to evaluate the impacts on a real groundwater system of specified hydrological stresses and/or to compare various scenarios in a decision-making process. However, and despite the professional care taken during the construction of the model and in conducting the simulations, its accuracy is bound to the normal uncertainty associated to groundwater modelling and no warranty, express or implied, is made.

9.0 CLOSURE

We trust this meets your current requirements. Should you have any questions or comments, please do not hesitate to contact us.

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Report Signature Page

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TABLES

Table 1A
Summary of Groundwater Model Input Parameters

Basic Model Construction - MODFLOW Grid Details

Number of Rows	261
Number of Columns	247
Number of Layers	15
Model Top	variable (as defined by topography)
Model Bottom	variable (as defined by Queenston Shale)

Hydraulic Properties of Model Hydrostratigraphic Units[1]

	Horizontal Hydraulic Conductivity, K_h (m/s)	Vertical Hydraulic Conductivity, K_v (m/s)	Specific Storage (m^{-1})	Specific Yield (-)	Effective Porosity (-)
Organic Deposits	5×10^{-5}	5×10^{-6}	1×10^{-5}	0.2	0.2
Glaciolacustrine Deposits	1×10^{-5}	1×10^{-6}	1×10^{-5}	0.2	0.2
Glaciofluvial Ice-Contact Deposits	5×10^{-4}	5×10^{-5}	1×10^{-5}	0.2	0.2
Glaciofluvial Outwash Deposits	5×10^{-4}	5×10^{-5}	1×10^{-5}	0.2	0.2
Weathered Elma Till	9×10^{-6}	9×10^{-7}	1×10^{-5}	0.2	0.2
Elma Till	7.5×10^{-6}	7.5×10^{-8}	1×10^{-5}	0.2	0.2
Weathered Catfish Creek Till	7.5×10^{-6}	7.5×10^{-7}	1×10^{-5}	0.2	0.2
Catfish Creek Till	2×10^{-7}	2×10^{-8}	1×10^{-5}	0.2	0.2
Weathered Bedrock	5×10^{-5}	5×10^{-6}	5×10^{-6}	0.05	0.05
Bedrock (Shallow Guelph-Gasport Aquifer)	1×10^{-8}	1×10^{-9}	1×10^{-6}	0.01	0.05
Bedrock (Intermediate Guelph-Gasport Aquifer)	1.5×10^{-5}	1.5×10^{-6}	1×10^{-6}	0.01	0.05
Bedrock (Deep Guelph-Gasport Aquifer)	1×10^{-8}	1×10^{-9}	1×10^{-6}	0.01	0.05
Bedrock (Bottom of Gasport to Top of Queenston Formations)	1×10^{-10}	1×10^{-10}	1×10^{-6}	0.01	0.05

Model Boundary Conditions - Recharge Rates [1]

Variable, ranging from 35 to 125 mm/yr.

Model Boundary Conditions - Constant Heads [2]

Western regional flow boundary	475 masl
Southern regional flow boundary	475 masl

Model Boundary Conditions - Site Drainage[2]

MODFLOW's Drain Boundary Condition was applied for surface drainage features over the model domain to simulate groundwater discharge. Surface drainage within the south-eastern portion of the model boundary is controlled by the headwater creeks and associated tributaries to the Grand River. Surface drainage in the remaining model area is controlled by numerous tributaries that drain towards the north-east (towards the Saugeen River, which lies outside the model domain).

Notes:

(1). Refer to Figure A7 for illustration of hydraulic conductivity distribution within the overburden model layers.

(2). See Figure A8 for illustration of the constant head and drainage boundary conditions applied.

Table 1B
Summary of Groundwater Model Input Parameters (2010 Model)

Basic Model Construction - MODFLOW Grid Details	
Number of Rows	251
Number of Columns	241
Number of Layers	9
Model Top	variable (as defined by topography)
Model Bottom	variable (as defined by Queenston Shale)

Hydraulic Properties of Model Hydrostratigraphic Units[1]

	Horizontal Hydraulic Conductivity, K_h (m/s)	Vertical Hydraulic Conductivity, K_v (m/s)	Effective Porosity
Organic Deposits	5×10^{-5}	5×10^{-6}	0.2
Glaciolacustrine Deposits	1×10^{-5}	1×10^{-6}	0.2
Glaciofluvial Ice-Contact Deposits	5×10^{-4}	5×10^{-5}	0.2
Glaciofluvial Outwash Deposits	5×10^{-4}	5×10^{-5}	0.2
Weathered Elma Till	9×10^{-6}	9×10^{-7}	0.2
Elma Till	7.5×10^{-6}	7.5×10^{-8}	0.2
Weathered Catfish Creek Till	7.5×10^{-6}	7.5×10^{-7}	0.2
Catfish Creek Till	2×10^{-7}	2×10^{-8}	0.2
Weathered Bedrock	5×10^{-5}	5×10^{-6}	0.05
Bedrock (Guelph/Amabel Formations)	2×10^{-5}	2×10^{-6}	0.05
Bedrock (Top of Cabot Head to Top of Queenston Formations)	1×10^{-10}	1×10^{-10}	0.05

Model Boundary Conditions - Recharge Rates [1]

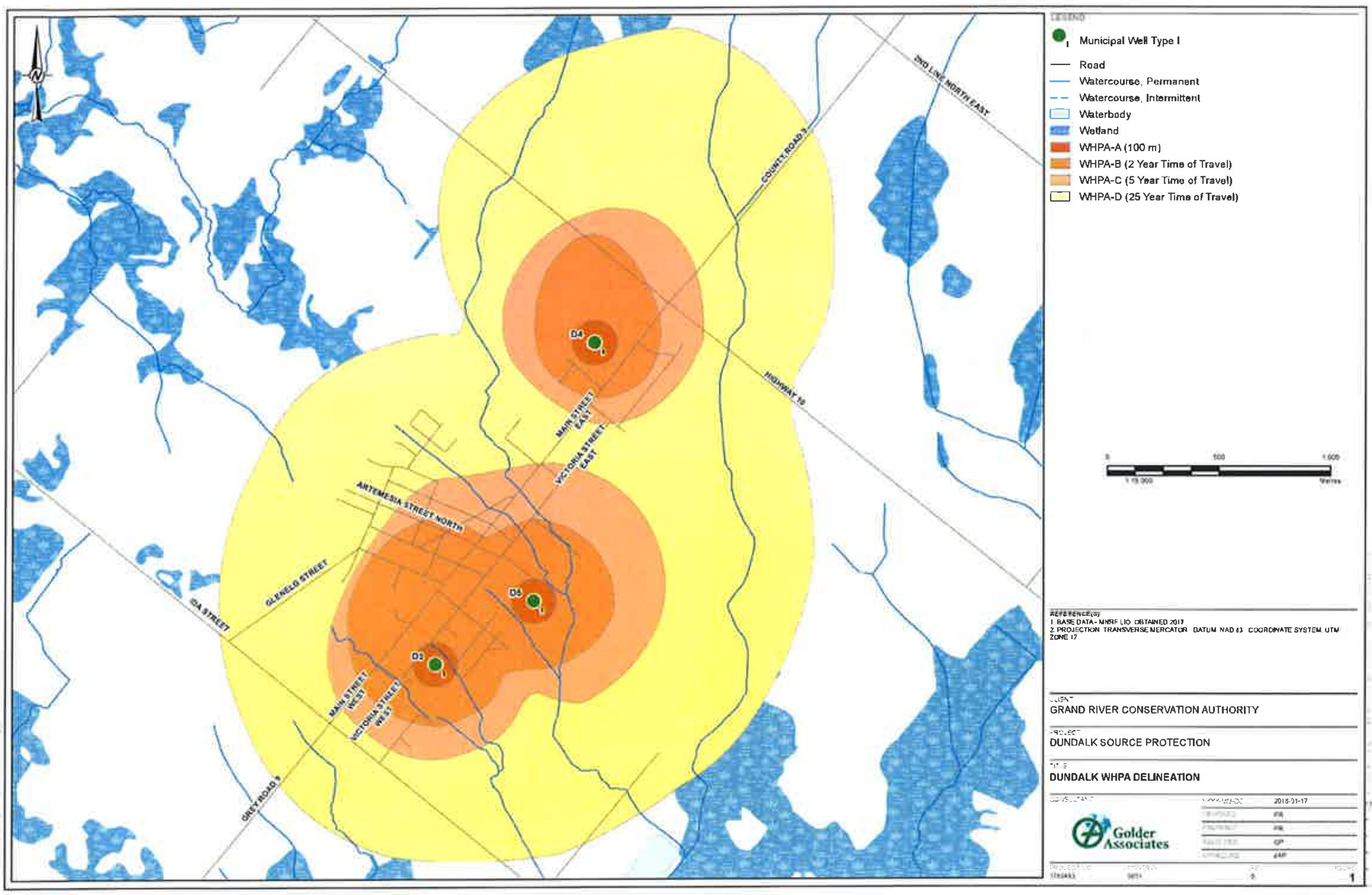
Variable, ranging from 35 to 150 mm/yr.

Model Boundary Conditions - Constant Heads [2]	
Western regional flow boundary	475 masl
Southern regional flow boundary	475 masl

Model Boundary Conditions - Site Drainage[2]

MODFLOW's Drain Boundary Condition was applied for surface drainage features over the model domain to simulate groundwater discharge. Surface drainage within the south-eastern portion of the model boundary is controlled by the headwater creeks and associated tributaries to the Grand River. Surface drainage in the remaining model area is controlled by numerous tributaries that drain towards the north-east (towards the Saugeen River, which lies outside the model domain).

FIGURES


LEGEND
Municipal Well Type I
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Watercourse, Permanent
Watercourse, Intermittent
Waterbody
Wetland
WHPA-A (100 m)
WHPA-B (2 Year Time of Travel)
WHPA-C (5 Year Time of Travel)
WHPA-D (25 Year Time of Travel)
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COUNTY ROAD 9
HIGHWAY 10
MAIN STREET EAST
VICTORIA STREET EAST
ARTEMESIA STREET NORTH
GLENELG STREET
IDA STREET
MAIN STREET WEST
VICTORIA STREET WEST
GREY ROAD 9
D4
D5
D3
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DUNDALK SOURCE PROTECTION
DUNDALK WHPA DELINEATION
2018-01-17
Golder Associates
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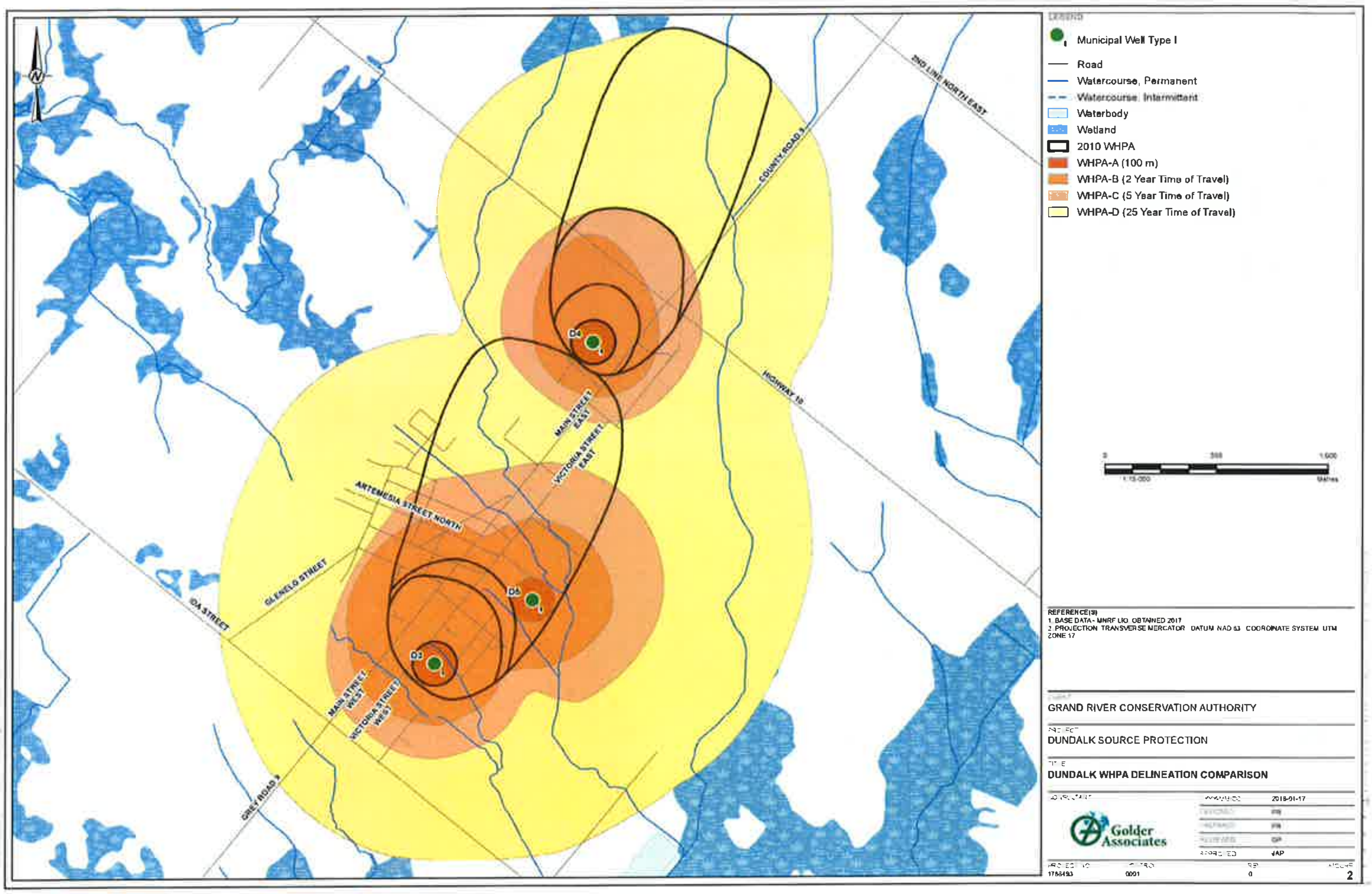
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Road
Watercourse, Permanent
Watercourse, Intermittent
Waterbody
Wetland
2010 WHPA
WHPA-A (100 m)
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WHPA-C (5 Year Time of Travel)
WHPA-D (25 Year Time of Travel)
2ND LINE NORTH EAST
COUNTY ROAD 9
HIGHWAY 10
MAIN STREET EAST
VICTORIA STREET EAST
ARTEMESIA STREET NORTH
GLENELG STREET
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VICTORIA STREET WEST
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D4
D5
D3
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Golder Associates
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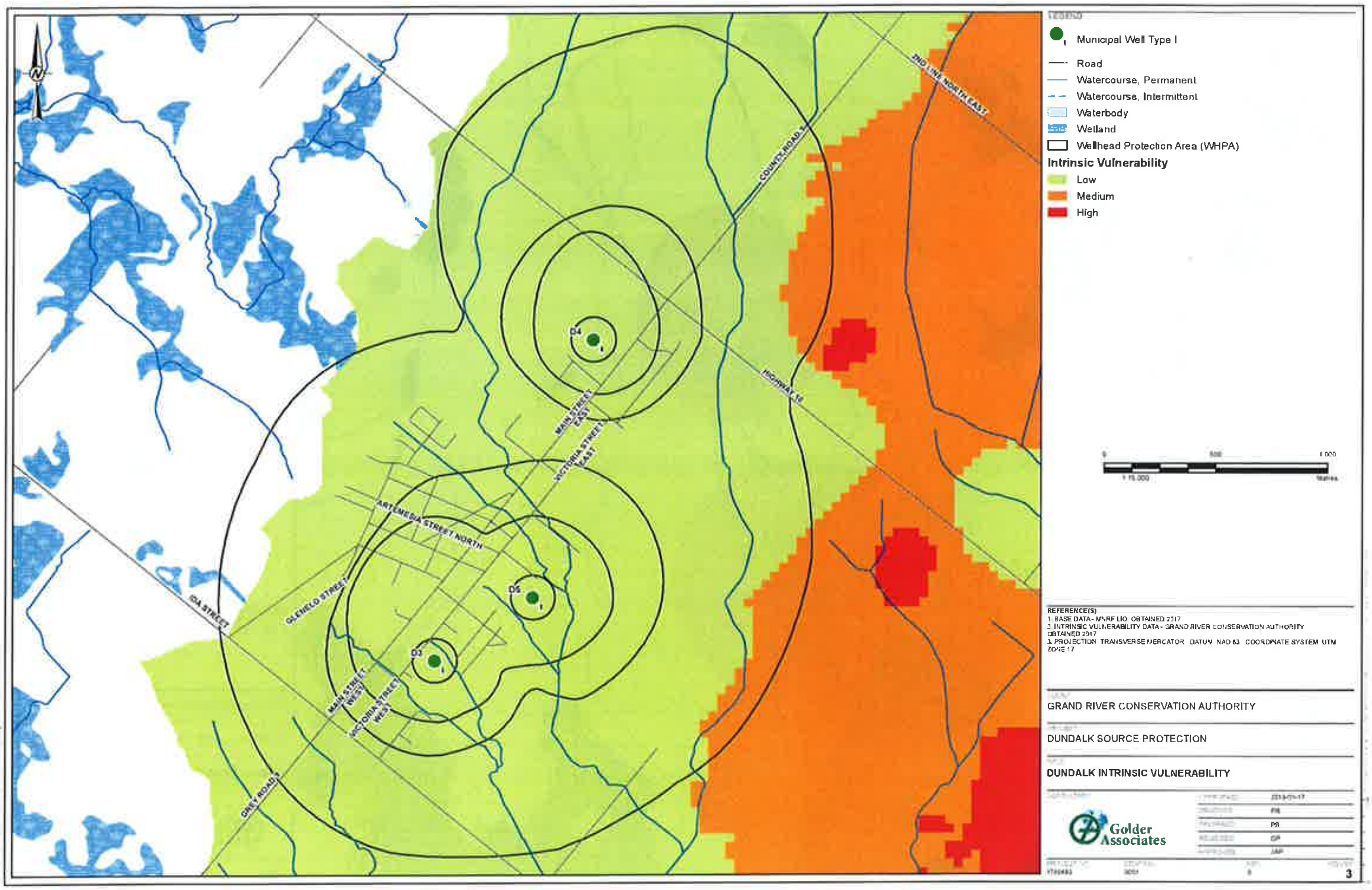
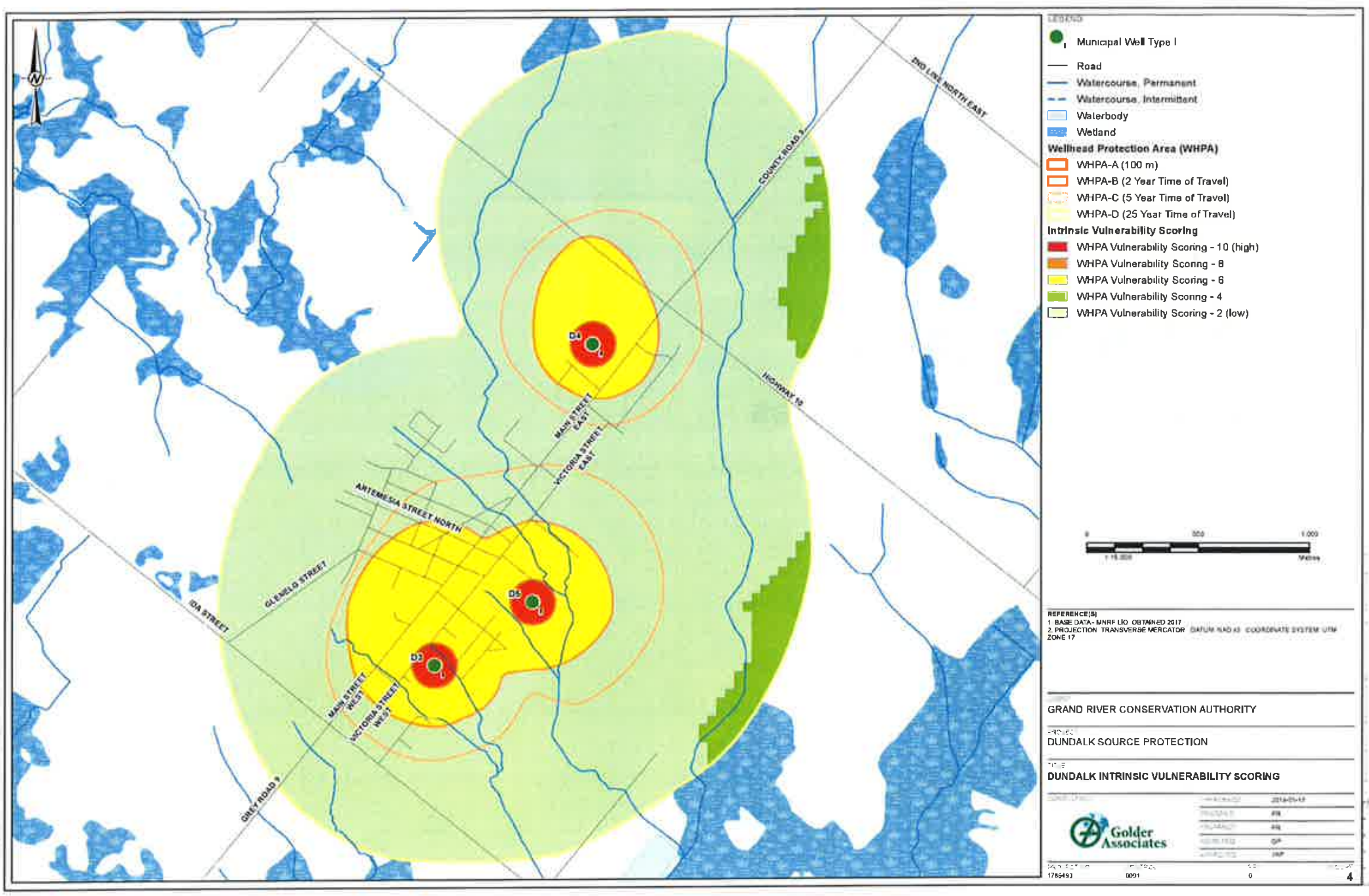


LEGEND
Municipal Well Type I
Road
Watercourse, Permanent
Watercourse, Intermittent
Waterbody
Wetland
Wellhead Protection Area (WHPA)
Intrinsic Vulnerability
Low
Medium
High
D4
D5
D3
2ND LINE NORTH EAST
COUNTY ROAD 9
HIGHWAY 10
MAIN STREET EAST
VICTORIA STREET EAST
ARTEMESIA STREET NORTH
GLENELG STREET
IDA STREET
MAIN STREET WEST
VICTORIA STREET WEST
GREY ROAD 9
REFERENCE(S)
1. BASE DATA - MNRF LIO. OBTAINED 2017
2. INTRINSIC VULNERABILITY DATA - GRAND RIVER CONSERVATION AUTHORITY OBTAINED 2017
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17
GRAND RIVER CONSERVATION AUTHORITY
DUNDALK SOURCE PROTECTION
DUNDALK INTRINSIC VULNERABILITY
Golder Associates
PR
PR
GP
JAP
3


LEGEND
Municipal Well Type I
Road
Watercourse, Permanent
Watercourse, Intermittent
Waterbody
Wetland
Wellhead Protection Area (WHPA)
WHPA-A (100 m)
WHPA-B (2 Year Time of Travel)
WHPA-C (5 Year Time of Travel)
WHPA-D (25 Year Time of Travel)
Intrinsic Vulnerability Scoring
WHPA Vulnerability Scoring - 10 (high)
WHPA Vulnerability Scoring - 8
WHPA Vulnerability Scoring - 6
WHPA Vulnerability Scoring - 4
WHPA Vulnerability Scoring - 2 (low)
2ND LINE NORTH EAST
COUNTY ROAD 9
HIGHWAY 10
MAIN STREET EAST
VICTORIA STREET EAST
ARTEMESIA STREET NORTH
GLENELG STREET
IDA STREET
MAIN STREET WEST
VICTORIA STREET WEST
GREY ROAD 9
D4
D5
D3
REFERENCE(S)
1. BASE DATA - MNRF LIO, OBTAINED 2017
2. PROJECTION: TRANSVERSE MERCATOR
ZONE 17
GRAND RIVER CONSERVATION AUTHORITY
DUNDALK SOURCE PROTECTION
DUNDALK INTRINSIC VULNERABILITY SCORING
Golder Associates
1786493
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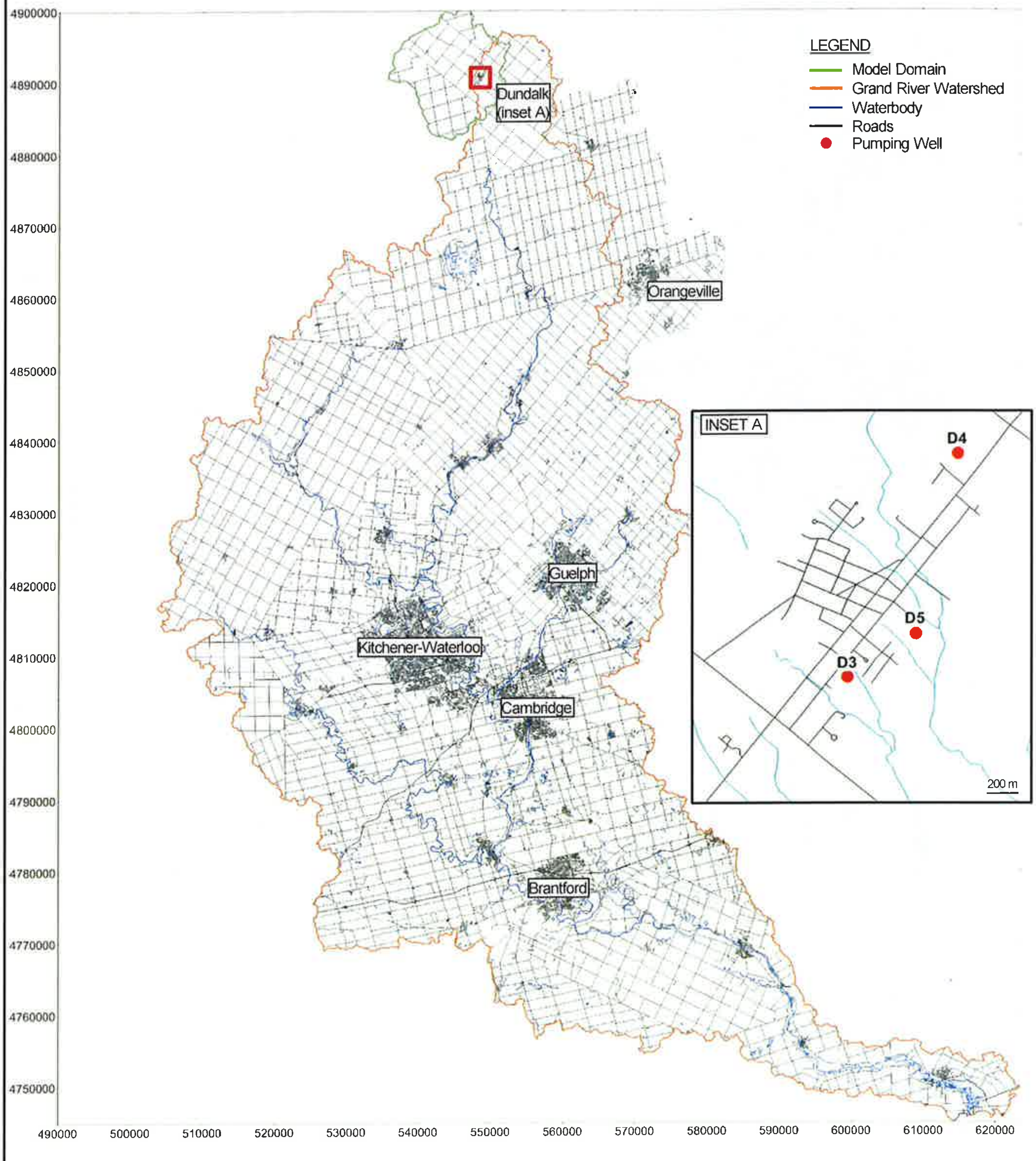
4

APPENDIX A

Model Construction Figures



CLIENT
GRAND RIVER CONSERVATION AUTHORITY

PROJECT
DUNDALK SOURCE PROTECTION

CONSULTANT

YYYY-MM-DD	2017-11-22
PREPARED	NFB
DESIGN	NFB
REVIEW	GRP
APPROVED	DH

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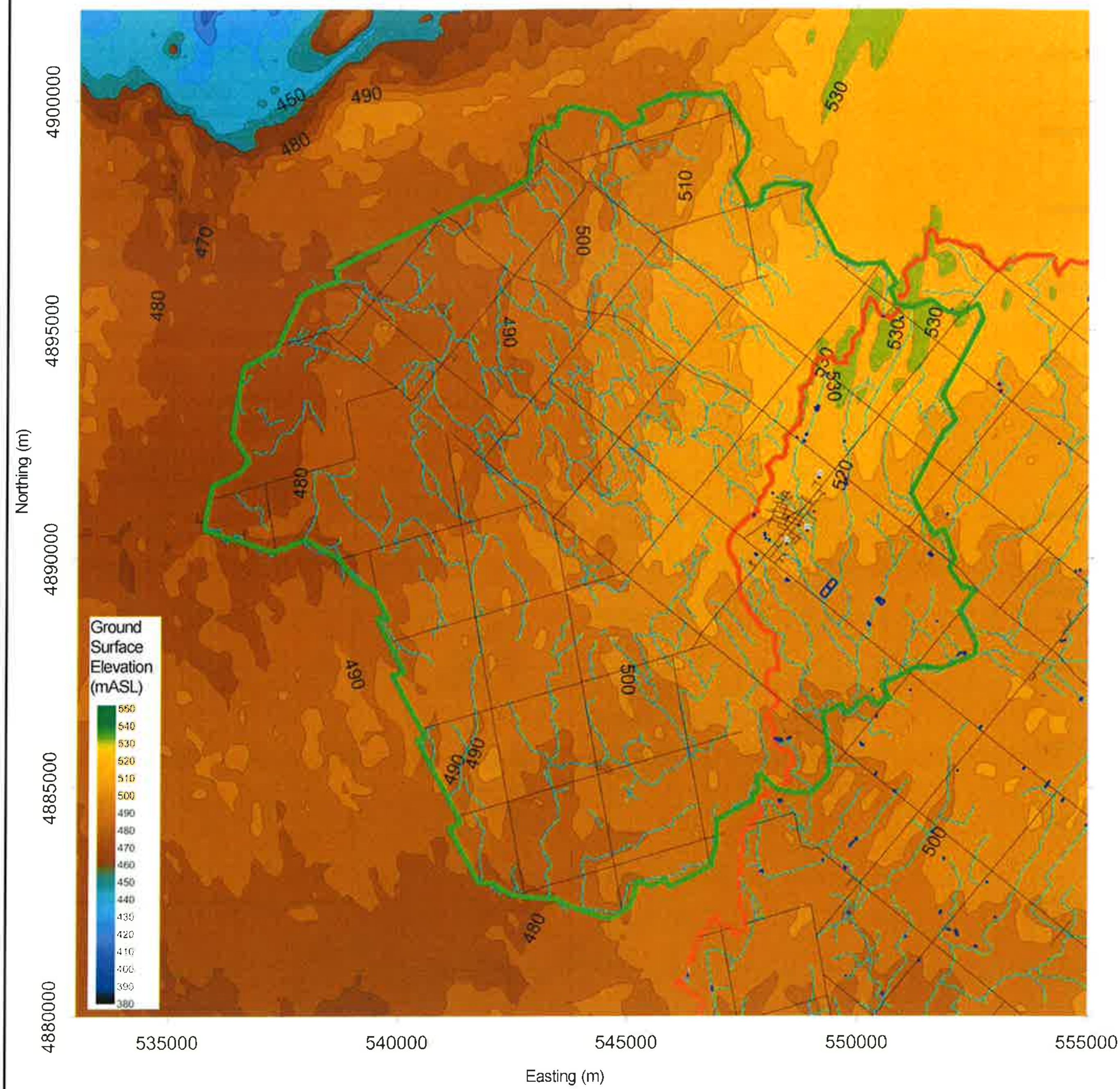
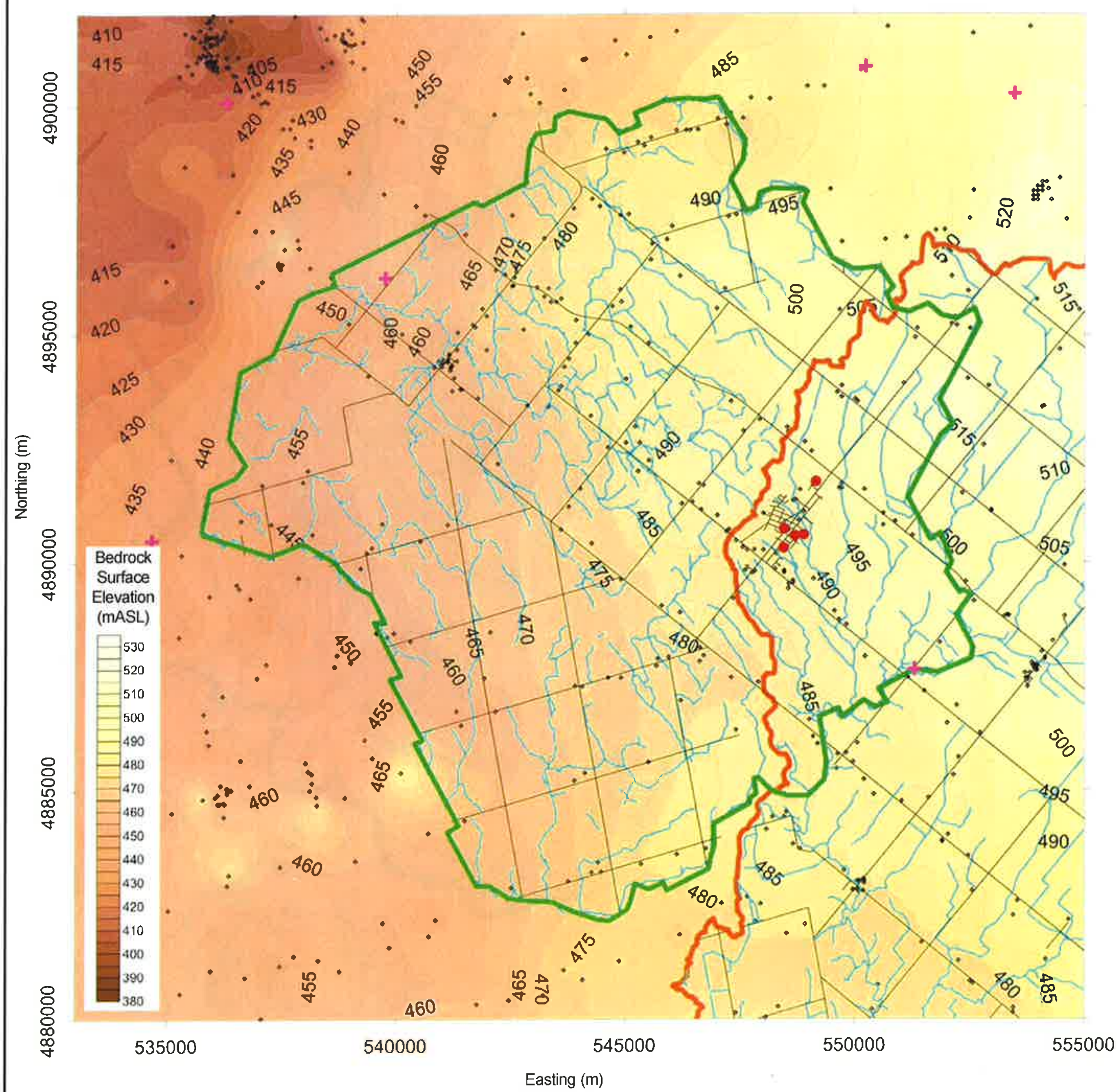
TITLE
SITE LOCATION

PROJECT No.	Rev.	FIGURE
1786493	0	A1



LEGEND
- Model Domain
- Grand River Watershed
- Waterbody
- Roads

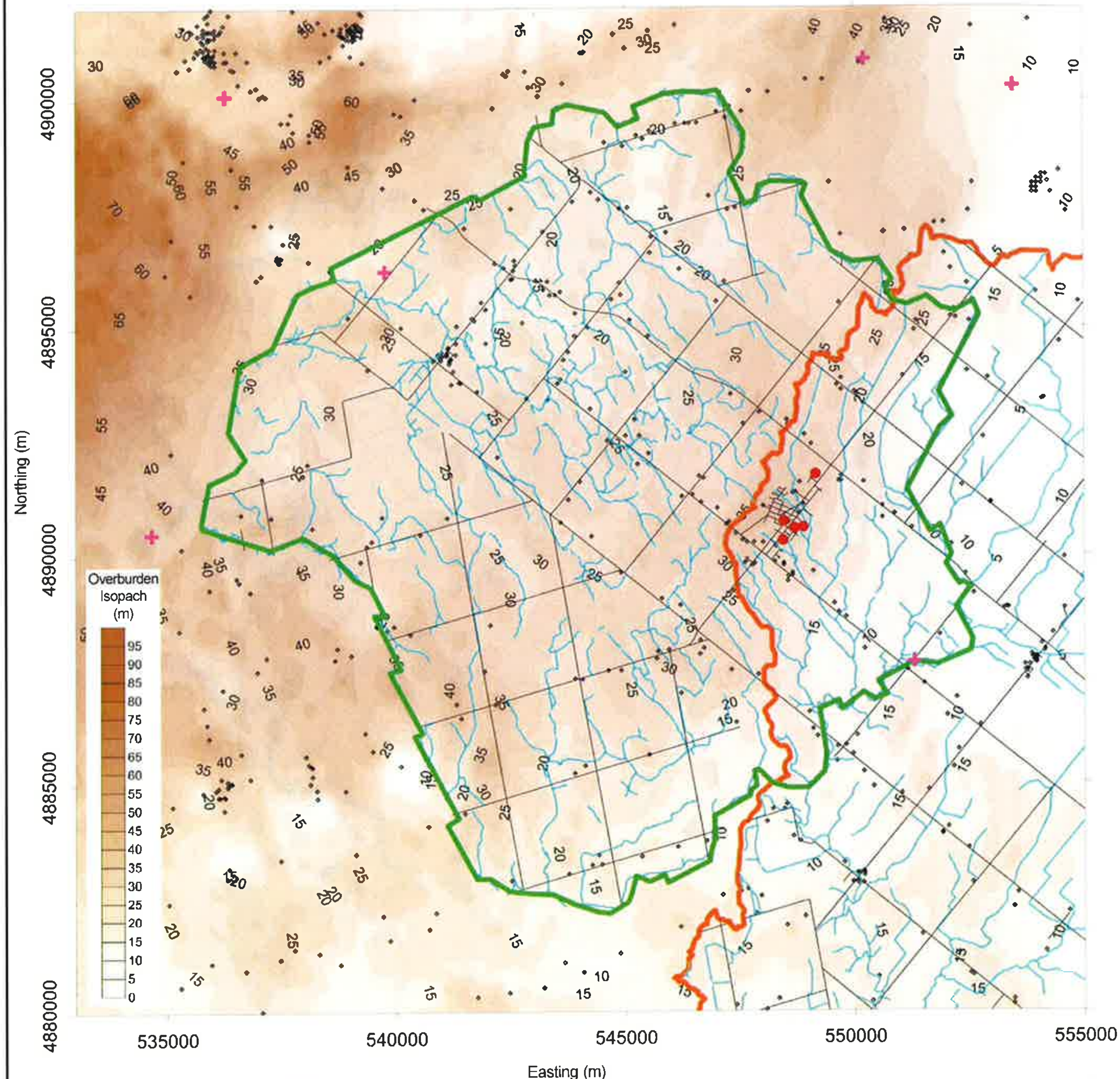
CLIENT GRAND RIVER CONSERVATION AUTHORITY		PROJECT DUNDALK SOURCE PROTECTION	
CONSULTANT Golder Associates	YYYY-MM-DD: 2017-11-22 PREPARED: NFB DESIGN: NFB REVIEW: GRP APPROVED: DH	TITLE TOPOGRAPHY AND DRAINAGE PROJECT No. 1786493	Rev. 0 FIGURE A2



LEGEND

- Model Domain
- Grand River Watershed
- Waterbody
- Roads
- Interpreted Bedrock Pick
- WWIS
- Municipal Well
- Oil and Gas Well

CLIENT GRAND RIVER CONSERVATION AUTHORITY		PROJECT DUNDALK SOURCE PROTECTION	
CONSULTANT Golder Associates	YYYY-MM-DD	2017-11-22	TITLE BEDROCK SURFACE ELEVATION
	PREPARED	NFB	
	DESIGN	NFB	
	REVIEW	GRP	
	APPROVED	DH	PROJECT No. 1786493 / Rev. 0 / FIGURE A3



LEGEND
- Model Domain
- Grand River Watershed
- Waterbody
- Roads
- Interpreted Bedrock Pick
- WWIS
- Municipal Well
- Oil and Gas Well

CLIENT
GRAND RIVER CONSERVATION AUTHORITY

PROJECT
DUNDALK SOURCE PROTECTION

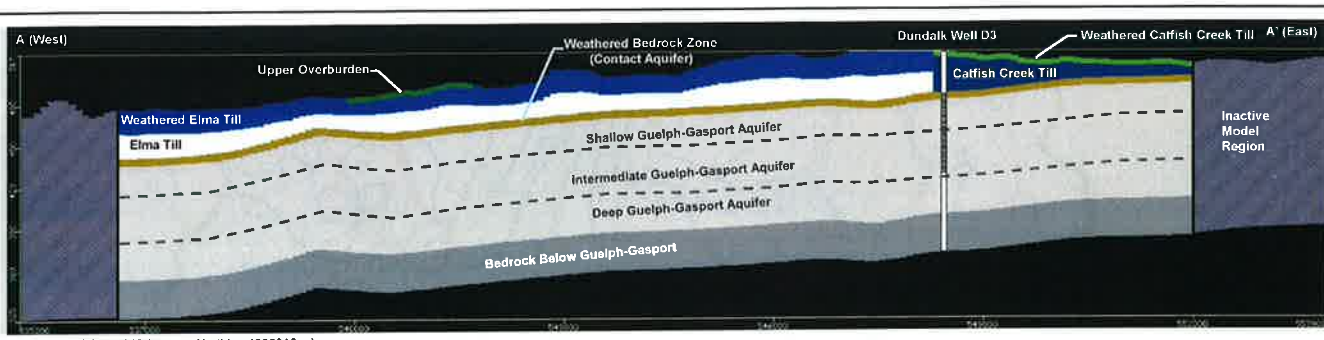
CONSULTANT

YYYY-MM-DD	2017-11-22
PREPARED	NFB
DESIGN	NFB
REVIEW	GRP
APPROVED	DH

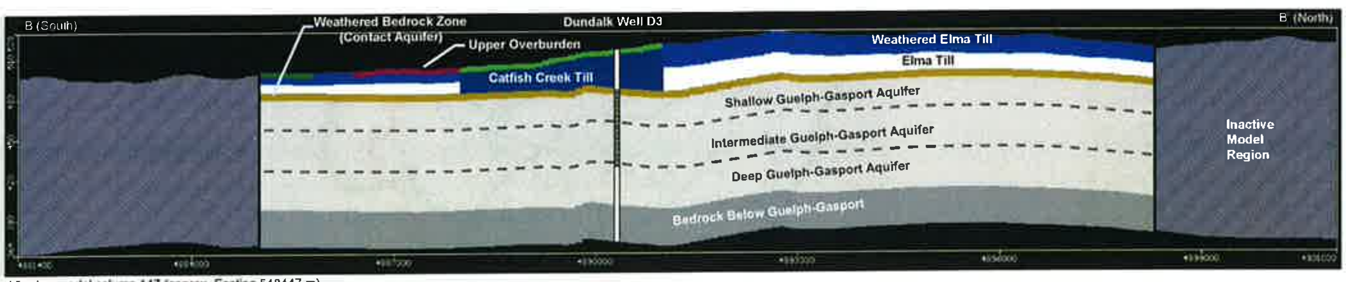
Golder Associates

TITLE
OVERBURDEN ISOPACH

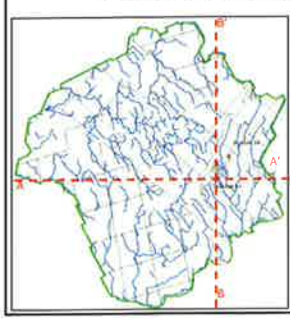
PROJECT No.	Rev.	FIGURE
1786493	0	A4



Viewing model row 148 (approx. Northing 4890316 m)



Viewing model column 147 (approx. Easting 548447 m)



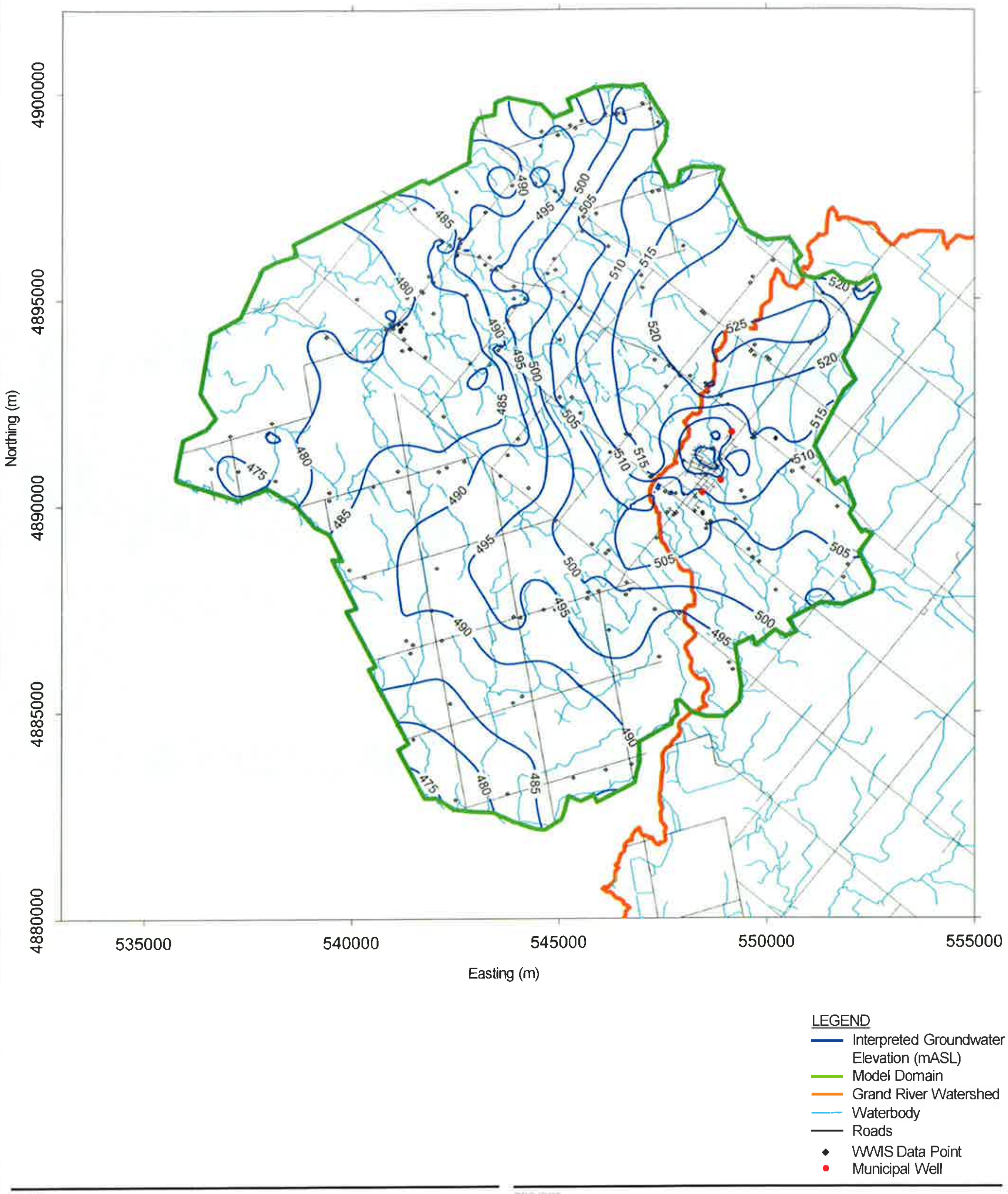
GRAND RIVER CONSERVATION AUTHORITY

DUNDALK SOURCE PROTECTION

SIMPLIFIED HYDROSTRATIGRAPHIC CROSS-SECTION

Golder Associates

1786493 | 0 | A5



CLIENT
GRAND RIVER CONSERVATION AUTHORITY

PROJECT
DUNDALK SOURCE PROTECTION

CONSULTANT

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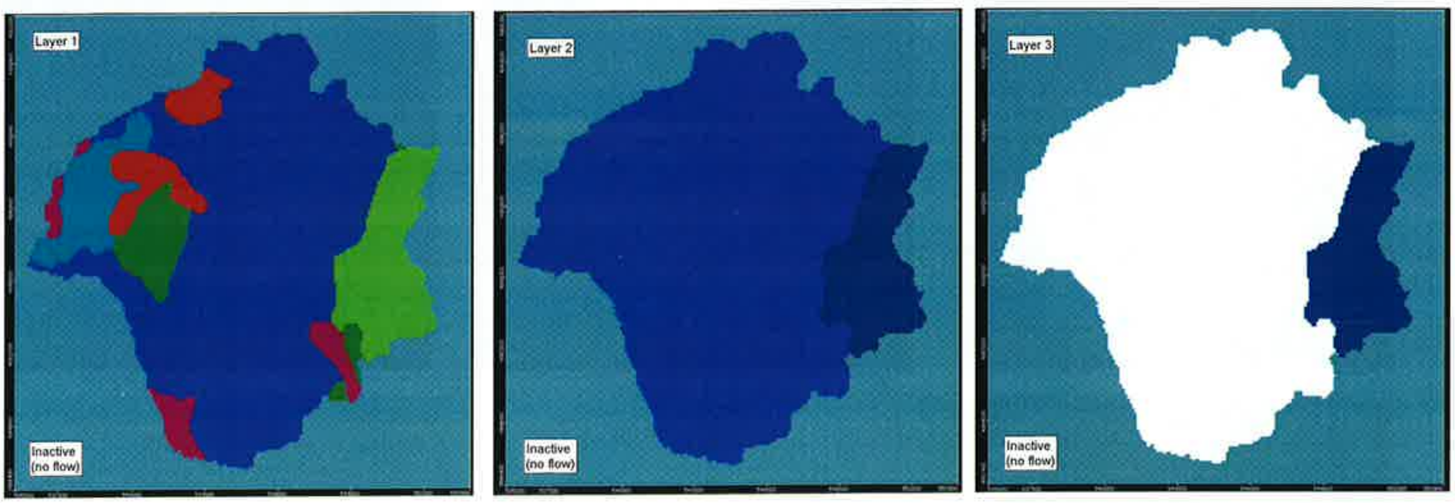
YYYY-MM-DD	2017-11-22
PREPARED	NFB
DESIGN	NFB
REVIEW	GRP
APPROVED	DH

TITLE
INTERPRETED GROUNDWATER ELEVATION

PROJECT No.	Rev.	FIGURE
1786493	0	A6



LEGEND

Unit (hydraulic conductivity [m/s])
- Weathered Elma Till (9E-6)
- Elma Till (7.5E-6)
- Organic Deposits (5E-5)
- Glaciolacustrine Deposits (1E-5)
- Glaciofluvial Ice-Contact Deposits (5E-4)
- Glaciofluvial Outwash Deposits (5E-4)
- Weathered Catfish Creek Till (7.5E-6)
- Catfish Creek Till (2E-7)

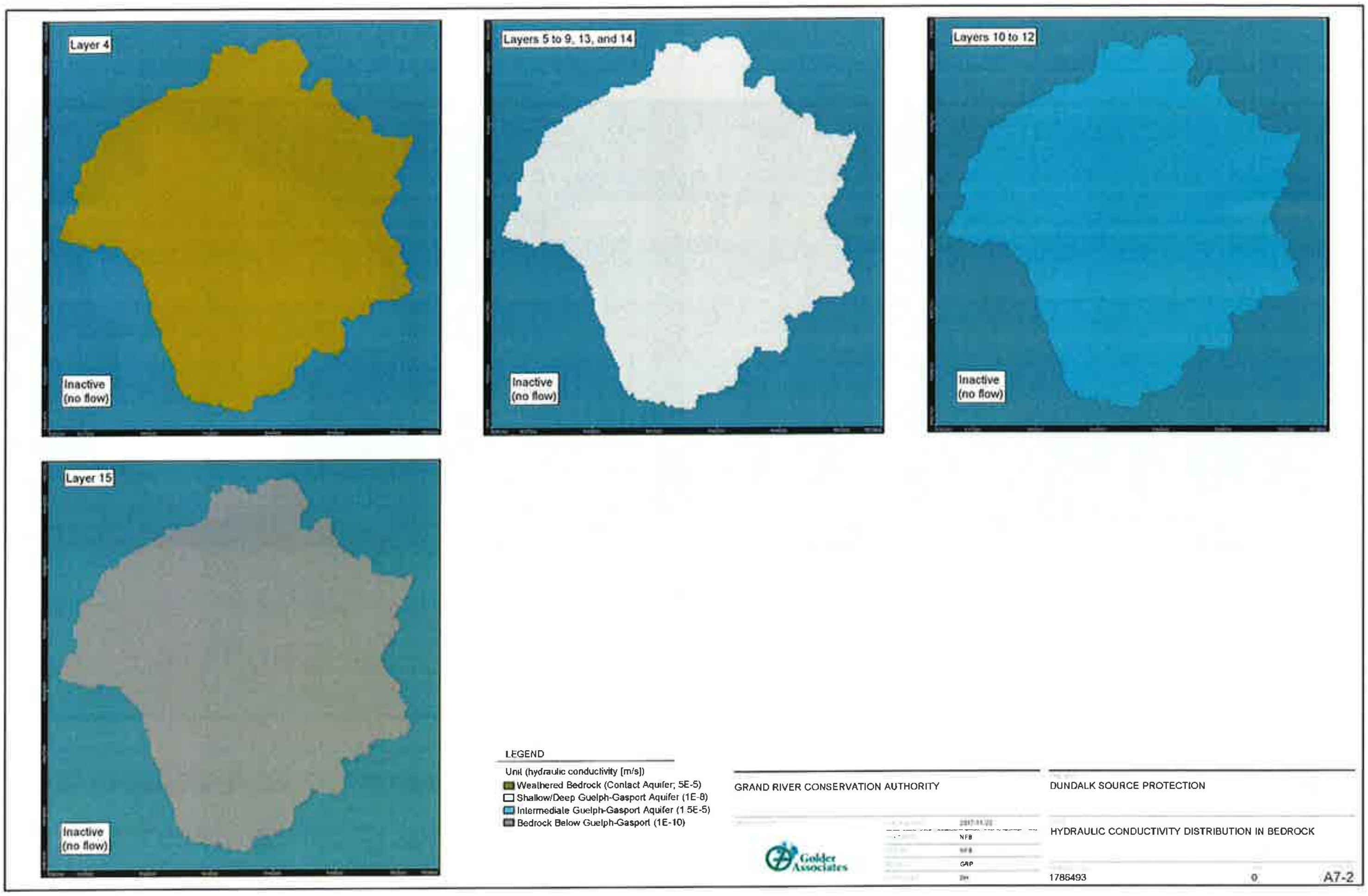
GRAND RIVER CONSERVATION AUTHORITY

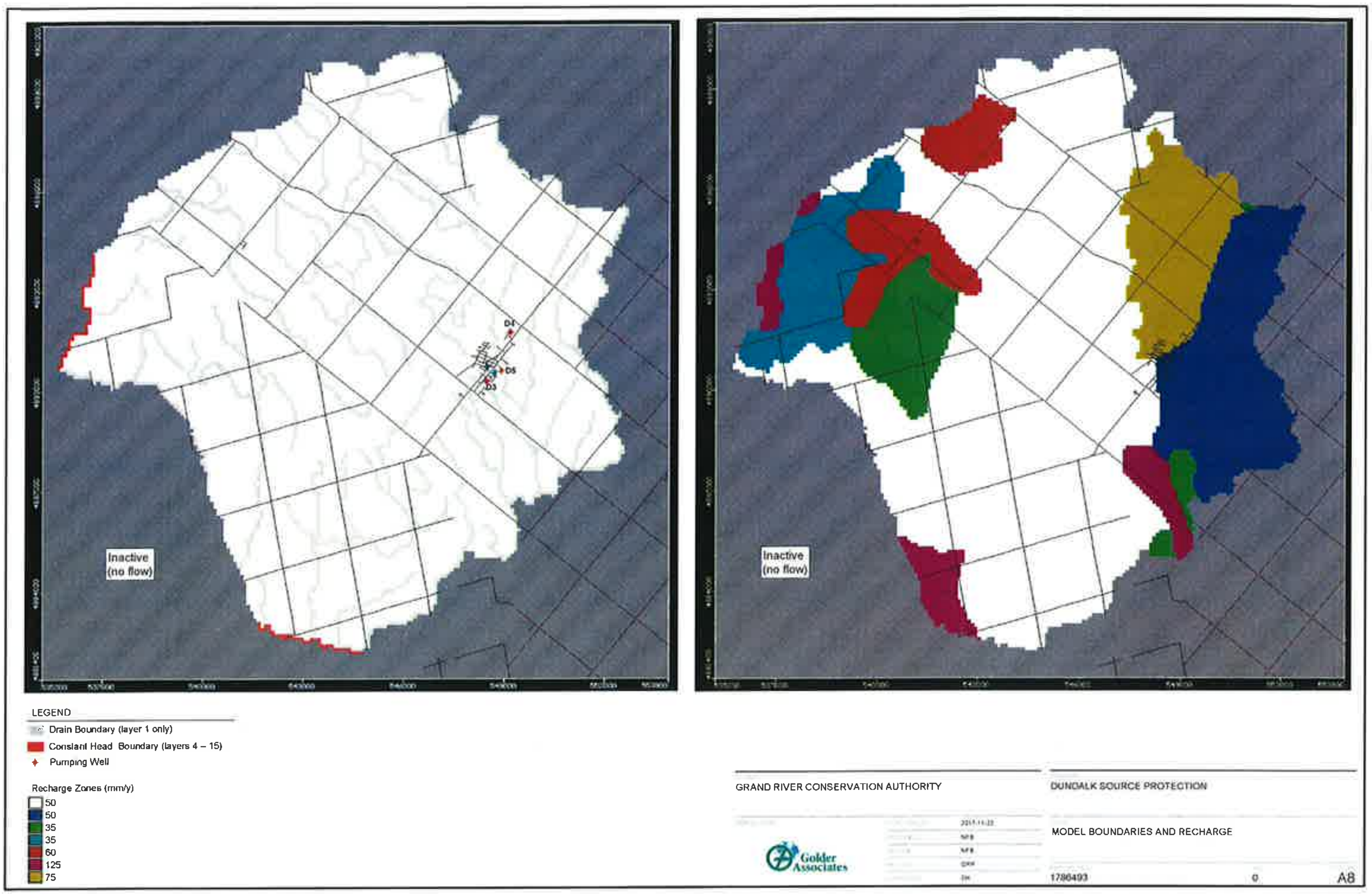
DUNDALK SOURCE PROTECTION

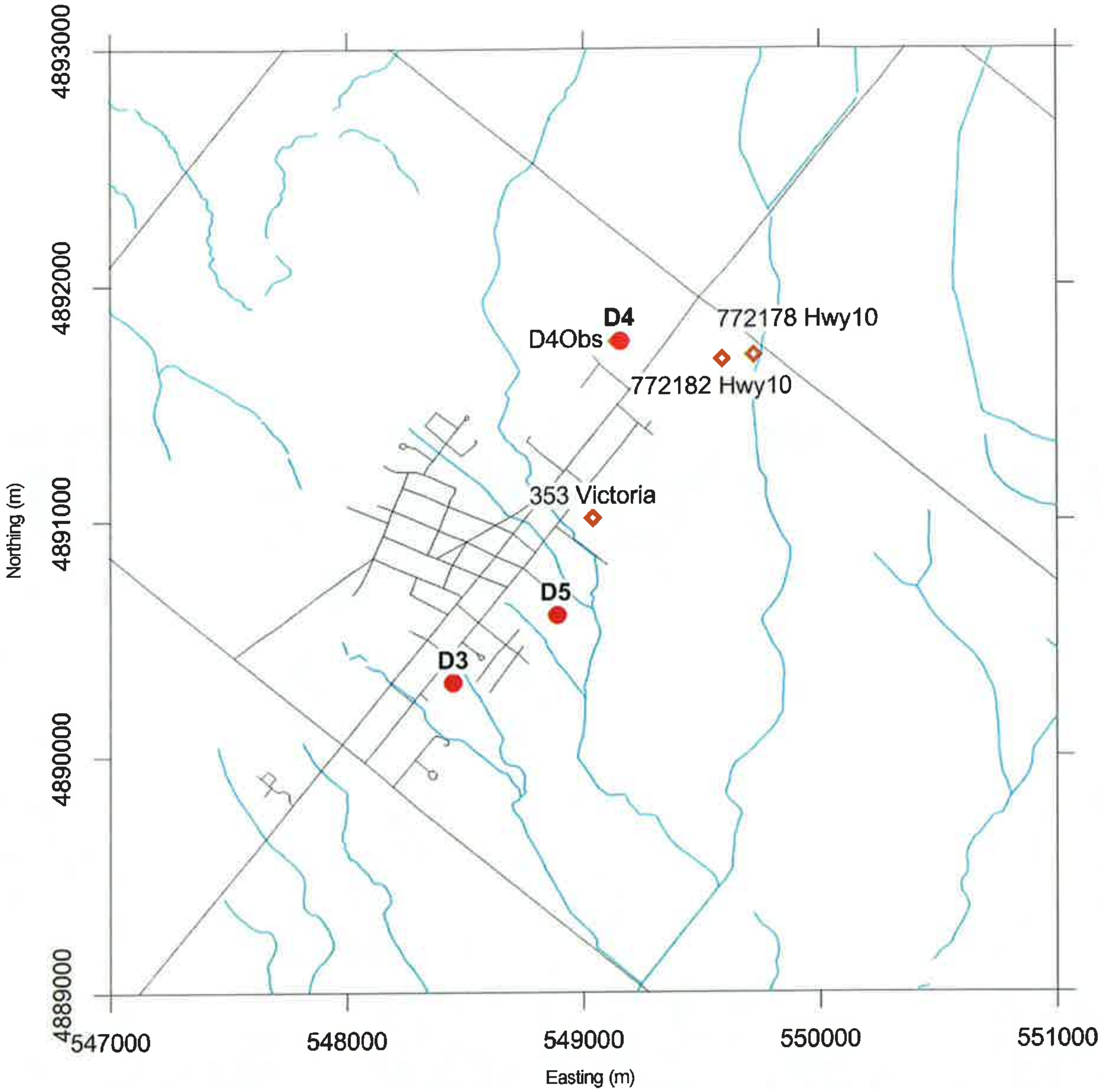
HYDRAULIC CONDUCTIVITY DISTRIBUTION IN OVERBURDEN

	NFB
	NFB
	GRP
	DH

1786493 0 A7-1


Layer 4
Inactive (no flow)
Layers 5 to 9, 13, and 14
Inactive (no flow)
Layers 10 to 12
Inactive (no flow)
Layer 15
Inactive (no flow)
LEGEND
Unit (hydraulic conductivity [m/s])
Weathered Bedrock (Contact Aquifer; 5E-5)
Shallow/Deep Guelph-Gasport Aquifer (1E-8)
Intermediate Guelph-Gasport Aquifer (1.5E-5)
Bedrock Below Guelph-Gasport (1E-10)
GRAND RIVER CONSERVATION AUTHORITY
Golder Associates
NFB
GRP
DUNDALK SOURCE PROTECTION
HYDRAULIC CONDUCTIVITY DISTRIBUTION IN BEDROCK
1786493
0
A7-2


D1
D5
D3
Inactive (no flow)
Inactive (no flow)
LEGEND
Drain Boundary (layer 1 only)
Constant Head Boundary (layers 4 – 15)
Pumping Well
Recharge Zones (mm/y)
50
50
35
35
60
125
75
GRAND RIVER CONSERVATION AUTHORITY
DUNDALK SOURCE PROTECTION
MODEL BOUNDARIES AND RECHARGE
Golder Associates
1786493
0
A8



Well	Easting (m)	Northing (m)	Ground Surface Elevation (mASL)	Depth (m)
353 Victoria Street North	549041	4891011	518	32
772178 Hwy 10	549721	4891703	518	28
772182 Hwy 10	549589	4891684	520	25*
D4Obs	549143	4891760	525	100.6

*Estimated by owner

CLIENT
GRAND RIVER CONSERVATION AUTHORITY

PROJECT
DUNDALK SOURCE PROTECTION

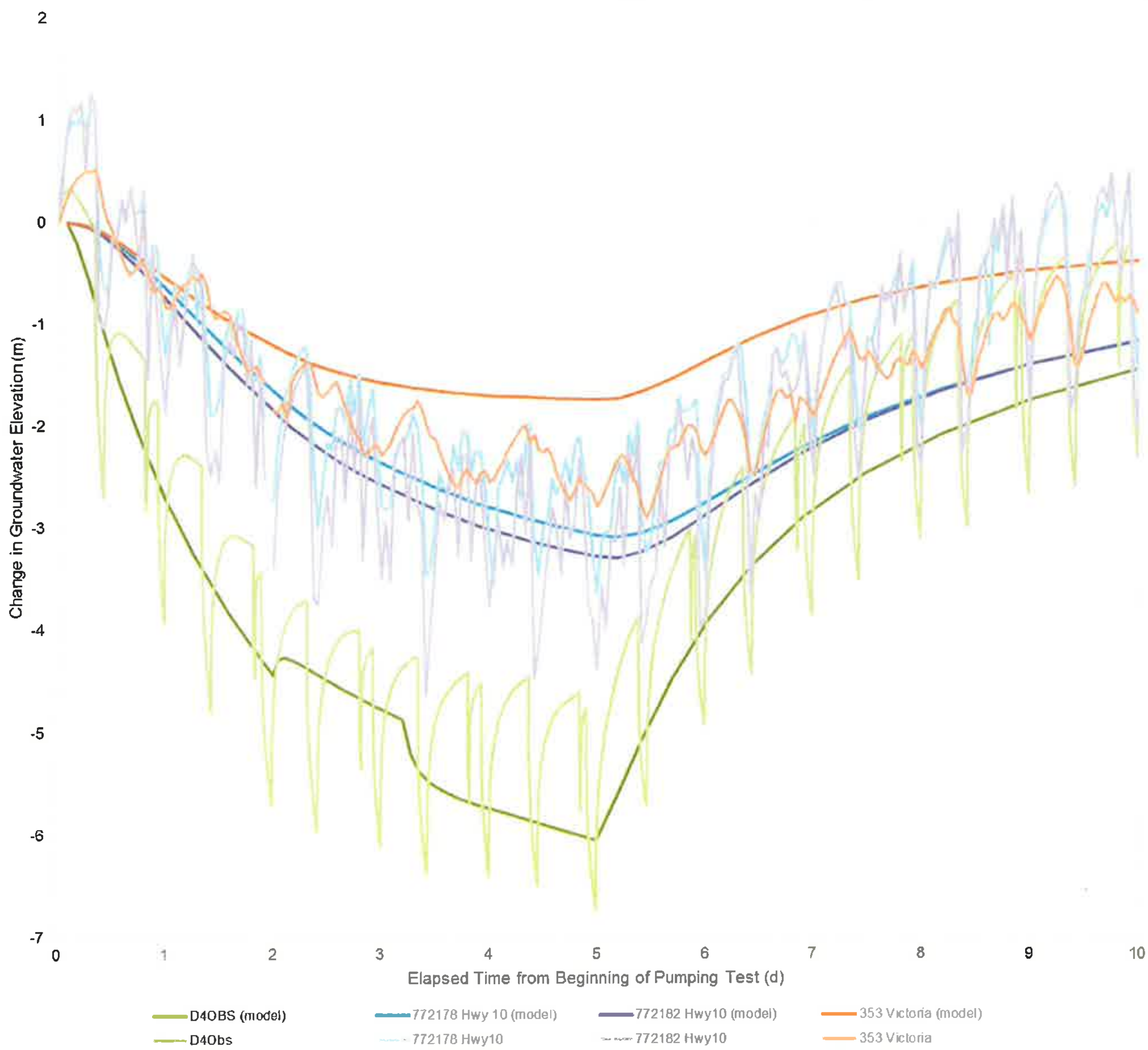
CONSULTANT

Golder Associates

YYYY-MM-DD	2017-11-22
PREPARED	NFB
DESIGN	NFB
REVIEW	GRP
APPROVED	DH

TITLE
WELL LOCATIONS AND COMPLETION INFORMATION

PROJECT No. 1786493
Rev. 0
FIGURE A9



CLIENT
GRAND RIVER CONSERVATION AUTHORITY

PROJECT
DUNDALK SOURCE PROTECTION

CONSULTANT

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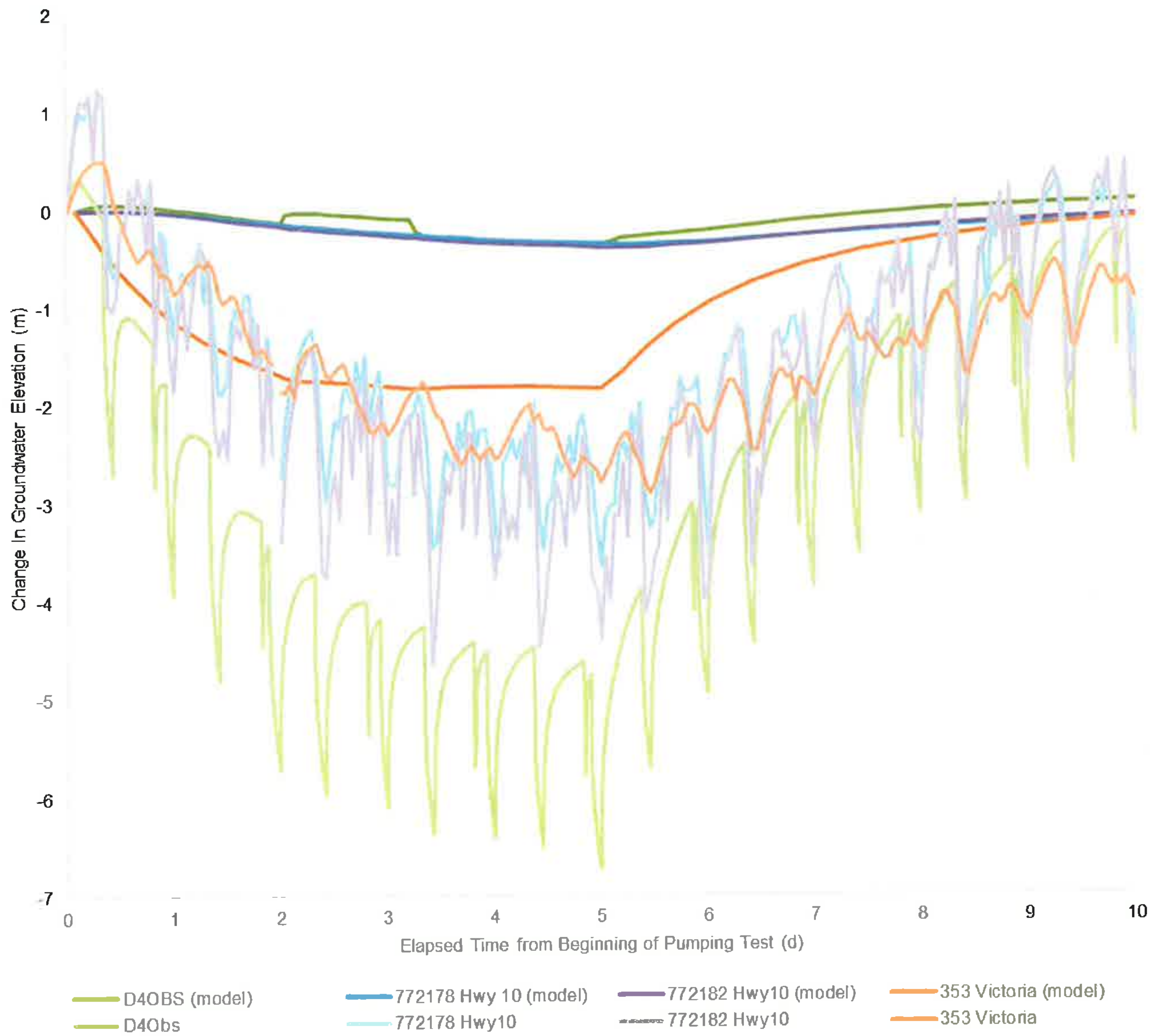
YYYY-MM-DD	2017-11-22
PREPARED	NFB
DESIGN	NFB
REVIEW	GRP
APPROVED	DH

TITLE
RESULTS OF THE TRANSIENT CALIBRATION

PROJECT No	Rev	FIGURE
1786493	0	A10-1



CLIENT
GRAND RIVER CONSERVATION AUTHORITY

PROJECT
DUNDALK SOURCE PROTECTION

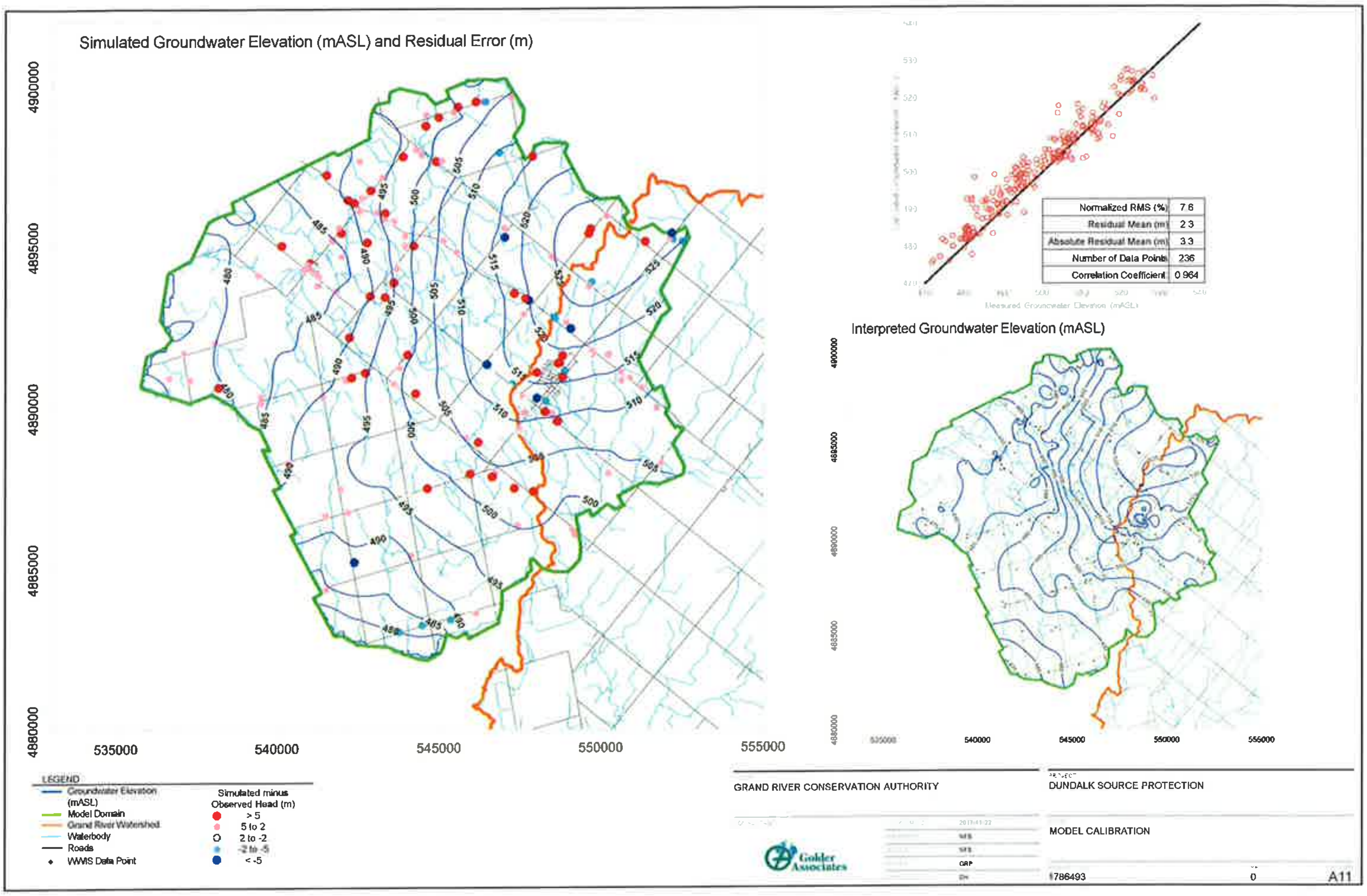
CONSULTANT

Golder Associates

YYYY-MM-DD	2017-11-22
PREPARED	NFB
DESIGN	NFB
REVIEW	GRP
APPROVED	DH

TITLE
RESULTS OF THE TRANSIENT CALIBRATION (2010 MODEL)

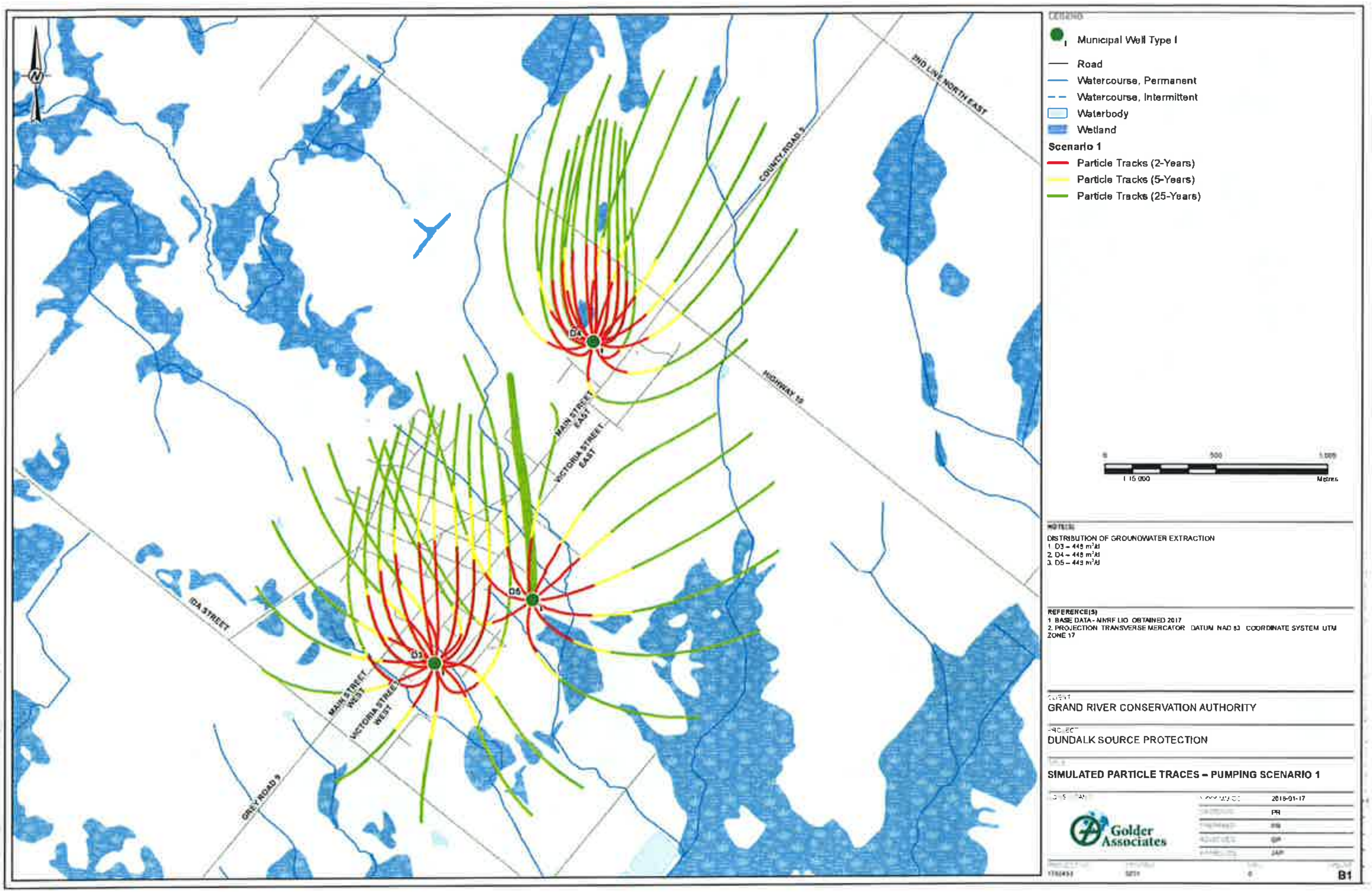
PROJECT No	Rev	FIGURE
1786493	0	A10-2



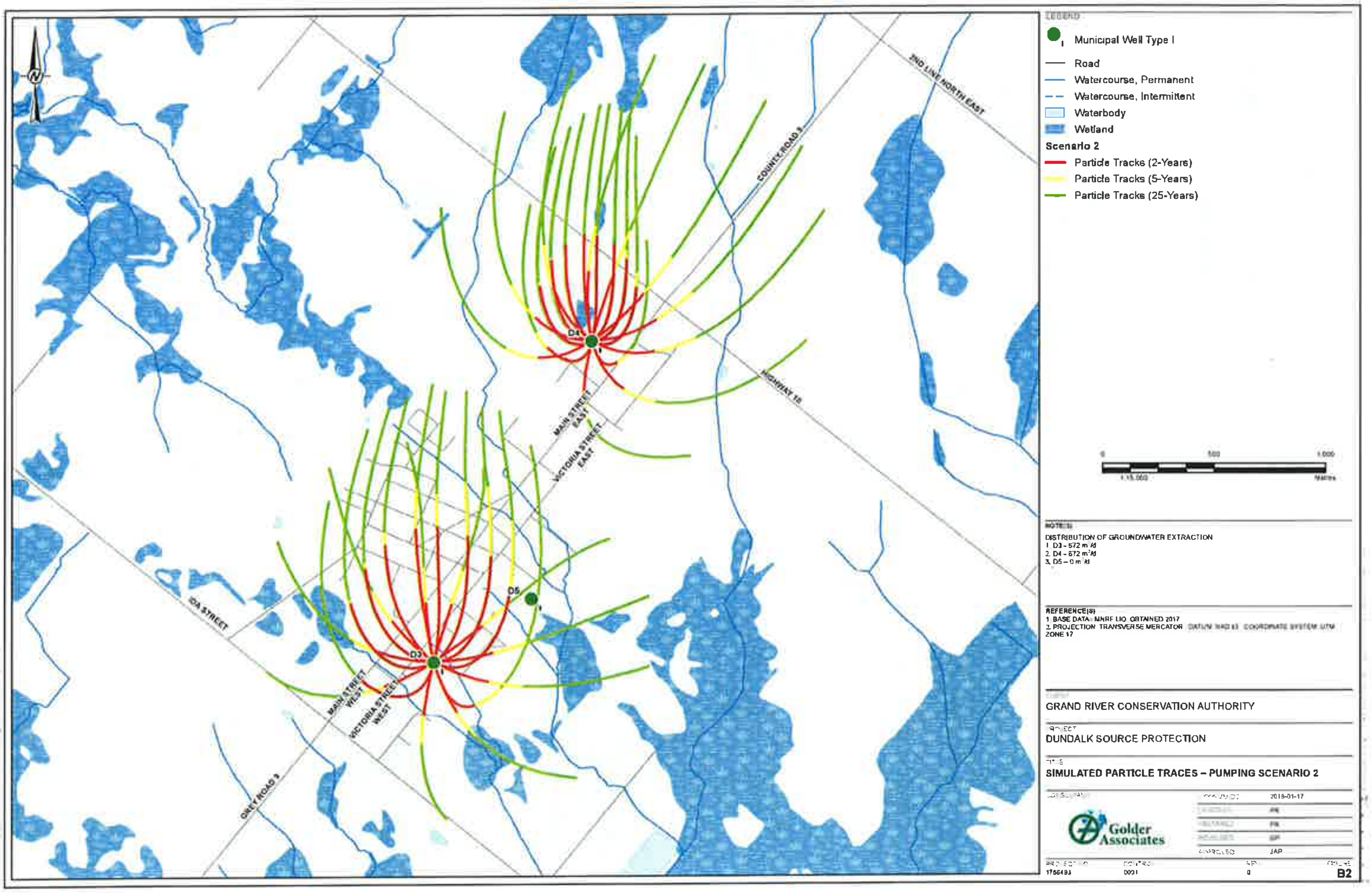
Simulated Groundwater Elevation (mASL) and Residual Error (m)
Normalized RMS (%) 7.8
Residual Mean (m) 2.3
Absolute Residual Mean (m) 3.3
Number of Data Points 236
Correlation Coefficient 0.964
Interpreted Groundwater Elevation (mASL)
535000
540000
545000
550000
555000
4880000
4885000
4890000
4895000
4900000
LEGEND
Groundwater Elevation (mASL)
Model Domain
Grand River Watershed
Waterbody
Roads
WWIS Data Point
Simulated minus Observed Head (m)
> 5
5 to 2
2 to -2
-2 to -5
< -5
GRAND RIVER CONSERVATION AUTHORITY
DUNDALK SOURCE PROTECTION
MODEL CALIBRATION
Golder Associates
1786493
0
A11

APPENDIX B

Pumping Scenarios Particle Track Figures



Municipal Well Type I
Road
Watercourse, Permanent
Watercourse, Intermittent
Waterbody
Wetland
Scenario 1
Particle Tracks (2-Years)
Particle Tracks (5-Years)
Particle Tracks (25-Years)
2ND LINE NORTH EAST
COUNTY ROAD 9
HIGHWAY 10
MAIN STREET EAST
VICTORIA STREET EAST
IDA STREET
MAIN STREET WEST
VICTORIA STREET WEST
GREY ROAD 9
D3
D4
D5
0
500
1:15 000
Metres
DISTRIBUTION OF GROUNDWATER EXTRACTION
1. D3 – 448 m³/d
2. D4 – 448 m³/d
3. D5 – 448 m³/d
REFERENCE(S)
1. BASE DATA - MNRF LIO OBTAINED 2017
2. PROJECTION TRANSVERSE MERCATOR DATUM NAD 83 COORDINATE SYSTEM UTM ZONE 17
GRAND RIVER CONSERVATION AUTHORITY
DUNDALK SOURCE PROTECTION
SIMULATED PARTICLE TRACES – PUMPING SCENARIO 1
Golder Associates
PR
B1



LEGEND
Municipal Well Type I
Road
Watercourse, Permanent
Watercourse, Intermittent
Waterbody
Wetland
Scenario 2
Particle Tracks (2-Years)
Particle Tracks (5-Years)
Particle Tracks (25-Years)
2ND LINE NORTH EAST
COUNTY ROAD 9
HIGHWAY 10
MAIN STREET EAST
VICTORIA STREET EAST
IDA STREET
MAIN STREET WEST
VICTORIA STREET WEST
GREY ROAD 9
D3
D4
D5
0
500
1,000
Metres
NOTE(S)
DISTRIBUTION OF GROUNDWATER EXTRACTION
1. D3 - 572 m³/d
2. D4 - 572 m³/d
3. D5 – 0 m³/d
REFERENCE(S)
1. BASE DATA: MNRF LIO, OBTAINED 2017
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17
GRAND RIVER CONSERVATION AUTHORITY
DUNDALK SOURCE PROTECTION
SIMULATED PARTICLE TRACES – PUMPING SCENARIO 2
Golder Associates
2018-01-17
PR
PR
GP
APPROVED
JAP
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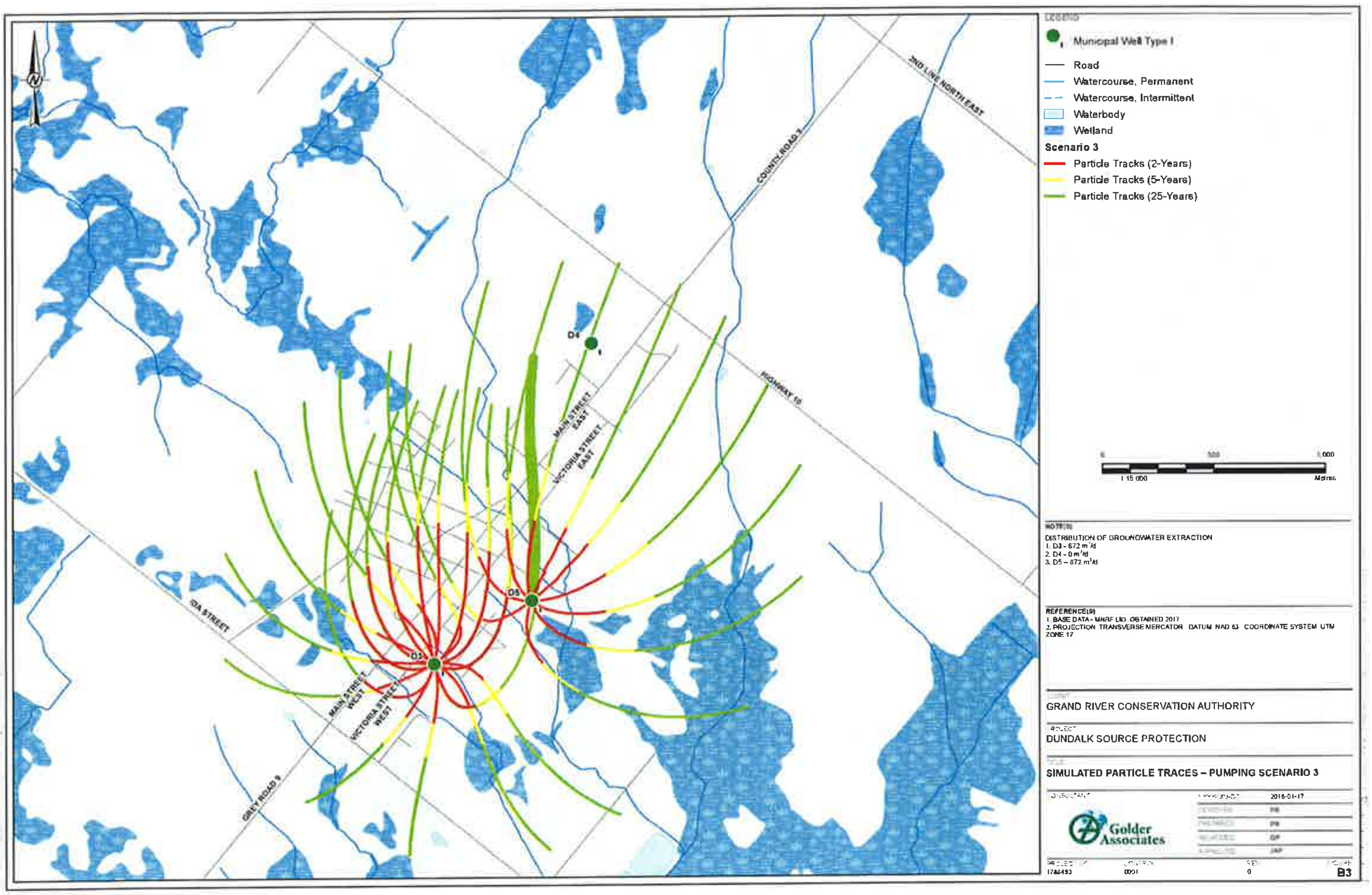
0
B2


Municipal Well Type I
Road
Watercourse, Permanent
Watercourse, Intermittent
Waterbody
Wetland
Scenario 3
Particle Tracks (2-Years)
Particle Tracks (5-Years)
Particle Tracks (25-Years)
2ND LINE NORTH EAST
COUNTY ROAD 9
HIGHWAY 10
MAIN STREET EAST
VICTORIA STREET EAST
IDA STREET
MAIN STREET WEST
VICTORIA STREET WEST
GREY ROAD 9
D4
D5
D3
0
1,000
1:15,000
Metres
DISTRIBUTION OF GROUNDWATER EXTRACTION
1. D3 - 672 m³/d
2. D4 - 0 m³/d
3. D5 – 672 m³/d
REFERENCE(S)
1. BASE DATA - MNRF LIO, OBTAINED 2017
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17
GRAND RIVER CONSERVATION AUTHORITY
DUNDALK SOURCE PROTECTION
SIMULATED PARTICLE TRACES – PUMPING SCENARIO 3
2018-01-17
PB
PB
GP
JAP
Golder Associates
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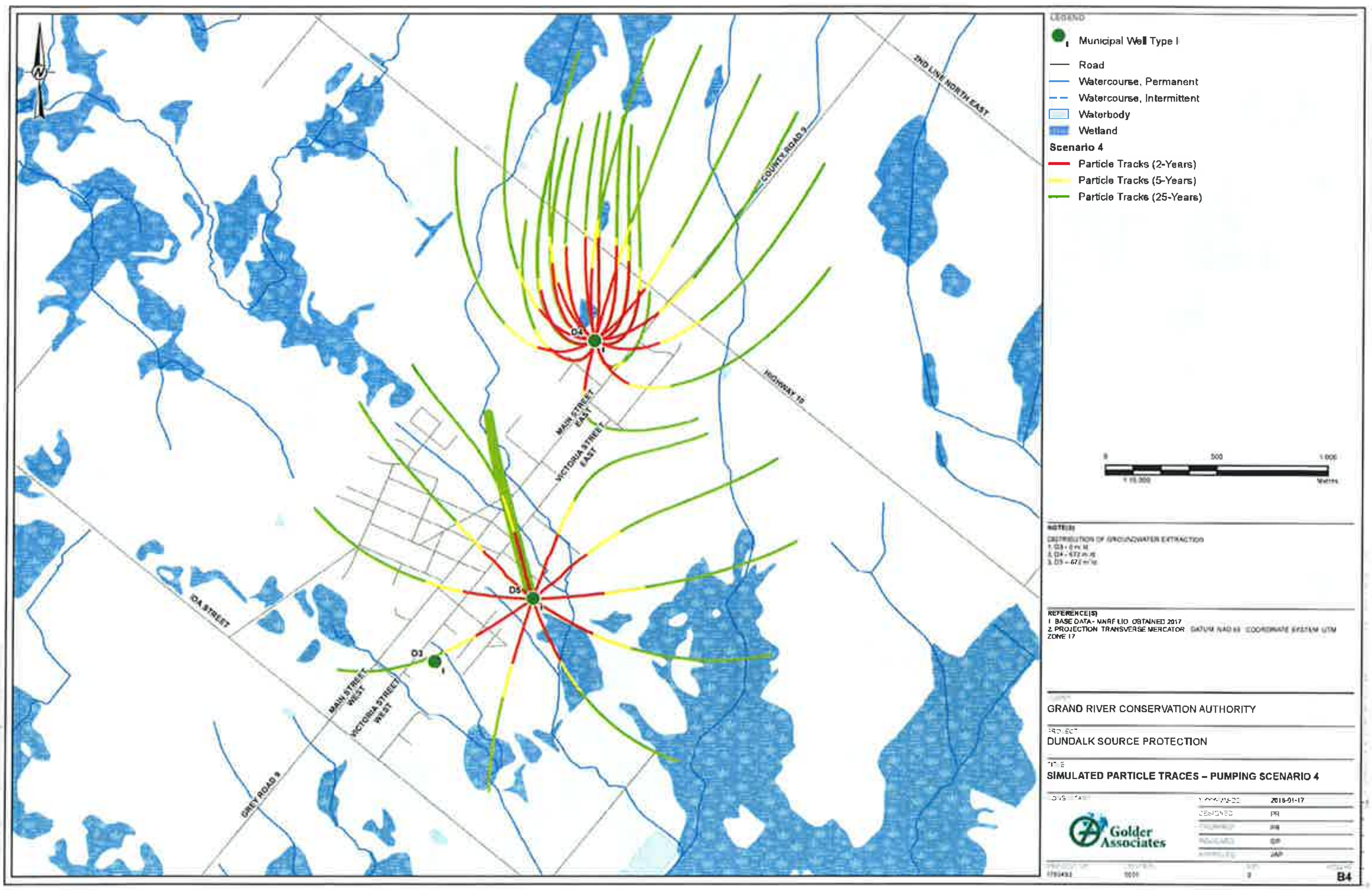
Municipal Well Type I
Road
Watercourse, Permanent
Watercourse, Intermittent
Waterbody
Wetland
Scenario 4
Particle Tracks (2-Years)
Particle Tracks (5-Years)
Particle Tracks (25-Years)
2ND LINE NORTH EAST
COUNTY ROAD 9
HIGHWAY 10
MAIN STREET EAST
VICTORIA STREET EAST
IDA STREET
MAIN STREET WEST
VICTORIA STREET WEST
GREY ROAD 9
D4
D5
D3
0
500
1,000
Metres
REFERENCE(S)
1. BASE DATA - MNRF LIO, OBTAINED 2017
2. PROJECTION: TRANSVERSE MERCATOR
ZONE 17
GRAND RIVER CONSERVATION AUTHORITY
DUNDALK SOURCE PROTECTION
SIMULATED PARTICLE TRACES – PUMPING SCENARIO 4
2018-01-17
PR
PR
DP
JAP
Golder Associates
B4

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Golder Associates

LAKE ERIE REGION SOURCE PROTECTION COMMITTEE

REPORT NO. SPC-18-04-06 **DATE:** April 5, 2018

TO: Members of the Lake Erie Region Source Protection Committee

SUBJECT: Dundalk Water Quality WHPA Update Technical Study

RECOMMENDATION:

THAT the Lake Erie Region Source Protection Committee receives report SPC-18-04-06 – Dundalk Water Quality WHPA Update Technical Study - for information.

AND THAT the Lake Erie Region Source Protection Committee direct staff to incorporate the results of the Dundalk Water Quality WHPA Update Technical Study into the Draft Updated Grand River Watershed Assessment Report.

SUMMARY:

Two groundwater supply wells, D3 and D4, currently provide municipal water to the Village of Dundalk. A third well, D5 has recently been constructed and will be brought online in the near future. Wellhead Protection Areas (WHPAs) were last delineated for wells D3 and D4 in 2010 using a groundwater flow model developed in 2007. As a part of this current study, the groundwater model was updated to incorporate well D5. WHPAs using current pumping rates, and vulnerability scores were then completed for the three municipal wells.

Results are recommended to be incorporated into the update to the Draft Updated Grand River Watershed Assessment Report.

REPORT:

System Overview

The Village of Dundalk is located in the Township of Southgate, County of Grey and is situated in the most northern part of the Grand River Watershed. The groundwater supply system for Dundalk consists of two bedrock wells referred to as D3 and D4. Well D3 was drilled in 1975 and is located in the south end of Dundalk. Well D4 was drilled in 2002 to replace wells D1 and D2 and is located northeast of the Village. The wells range in depth from approximately 87 metres (m) below ground surface (bgs) at D3 to 101 m bgs at D4.

An exploratory drilling and testing program was initiated to address the need for a third groundwater supply well. A new well referred to as D5 was constructed on the east side of Dundalk between wells D3 and D4. The well was constructed in 2016 to a depth of approximately 96 m bgs. A long-term pumping test was conducted at the well in January 2017. The new well will provide an additional groundwater source and will become part of the Dundalk groundwater supply system.

Wellhead Protection Areas

Within the area of the groundwater supply wells the bedrock surface is generally highest in the east and slopes towards the west. This corresponded to interpreted overburden thicknesses ranging from approximately 5 m in the east to over 40 m in the southwest. The uppermost bedrock formation (Guelph through Gasport) is estimated to be 88 m thick. Groundwater supply wells are completed within this portion of the bedrock sequence and the Guelph to Gasport Formations form the active municipal groundwater system. The municipal aquifer is mainly overlain by drumlinized till plains, locally characterized as Elma Till and Catfish Creek Till.

The numerical groundwater model developed as a part of the 2003 Grey and Bruce Groundwater Studies (and its subsequent updates in 2007 and 2010), was used as the starting point for the construction of the current model. The model was updated to incorporate the new municipal supply well using refined bedrock geology. The refined bedrock geology interpretation divides the portion of the Guelph-Gasport aquifer below the contact aquifer zone into three hydrostratigraphic units: a shallow zone of lower permeability, an intermediate zone of higher permeability, and a deep zone of lower permeability. In addition, the upper surface of the till unit was assumed to be impacted by weathering, therefore having a higher hydraulic conductivity in the upper portion of the unit.

The pumping rates used to determine the WHPAs are based on the allocated quantity of water. In each scenario, the allocated quantity of water or the total pumping rate for the wellfield was 1,344 m^3/day. This is based on an estimate of the 20- year forecast planned demand provided by Triton Engineering, which represents the existing average day demand over the past three years for 1,799 people (490 m^3/day), plus a committed demand over the next 10 years for 2,111 people (574 m^3/day) and a planned demand for the next 20 years for 1,028 people (280 m^3/day).The WHPAs for Dundalk wells D3, D4, and D5 were determined by running the model with four different scenarios to represent possible combinations of future pumping from the wells, as summarized in Table 1 below.

Table 1: Simulated Pumping Rates for WHPA Delineation

Well	Forecast Pumping Rate (m^3/day)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
D3	448	672	672	0
D4	448	672	0	672
D5	448	0	672	672

The resulting WHPAs are shown on **Figure 1**. The outline of the 2010 WHPAs are also shown on **Figure 1**. Generally, the WHPAs extend north-northeast from the village in the direction (upgradient) of local groundwater flow through the bedrock. A comparison of the new WHPAs to the previous WHPAs indicates the new WHPAs are more “rounded” and extend further out from the supply wells compared to the previous WHPAs. Differences between the 2010 and 2017 WHPA shape and size result from a number of factors including:

- An increase in wellfield pumping from 854 m^3/day to 1,344 m^3/day,
- Pumping at 3 wells compared to 2 wells, and
- Revised conceptual model now includes the bedrock aquifer divided into three layers.

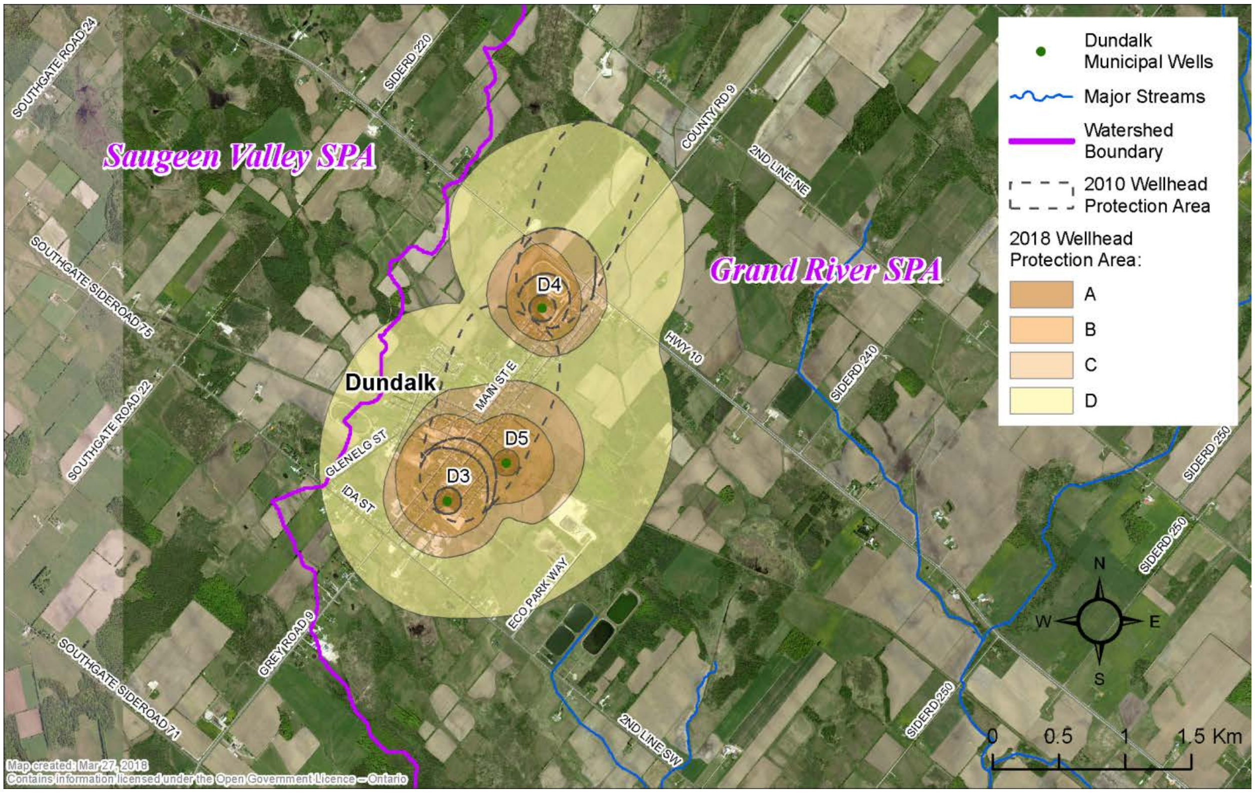

Figure 1: Dundalk WHPAs. Dashed lines represent WHPAs developed in 2010.

Wells D3, D4 and D5 are classified as non-GUDI and hence a WHPA-E was not delineated. Delineation of a WHPA-F was not required based on the absence of a WHPA-E.

Vulnerability Scoring

Regional vulnerability work was completed using the Surface to Aquifer Advective Time (SAAT) method. Within the WHPAs, the vulnerability of the aquifers was scored as in Table 2.

Table 2: WHPA Vulnerability Scores – SAAT

Groundwater Vulnerability Category	**Location Within a Wellhead Protection Area**			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
High	10	10	8	6
Medium	10	8	6	4
Low	10	6	2	2

The resulting map with vulnerability scores within the new WHPAs is shown on **Figure 2**. Most of the area within the WHPA is considered low vulnerability with some medium vulnerability in the eastern edge of the WHPA.

The Technical Rules allow for an increase in the vulnerability where man-made transport pathways can decrease the time for contaminants to reach a water supply source. Potential preferential pathways reviewed as part of this study include existing wells or boreholes, unused or abandoned wells, pits, quarries and areas licensed for aggregate extraction, mines, construction activities, septic systems, storm water infiltration, and municipal underground services. Most of the potential preferential pathways are shallow (excluding wells) compared to the thickness of the aquitard overlying the municipal aquifer (i.e., they do not breach the aquitard) therefore, the risk factor for potential preferential pathways was considered low and no changes to the vulnerability were made.

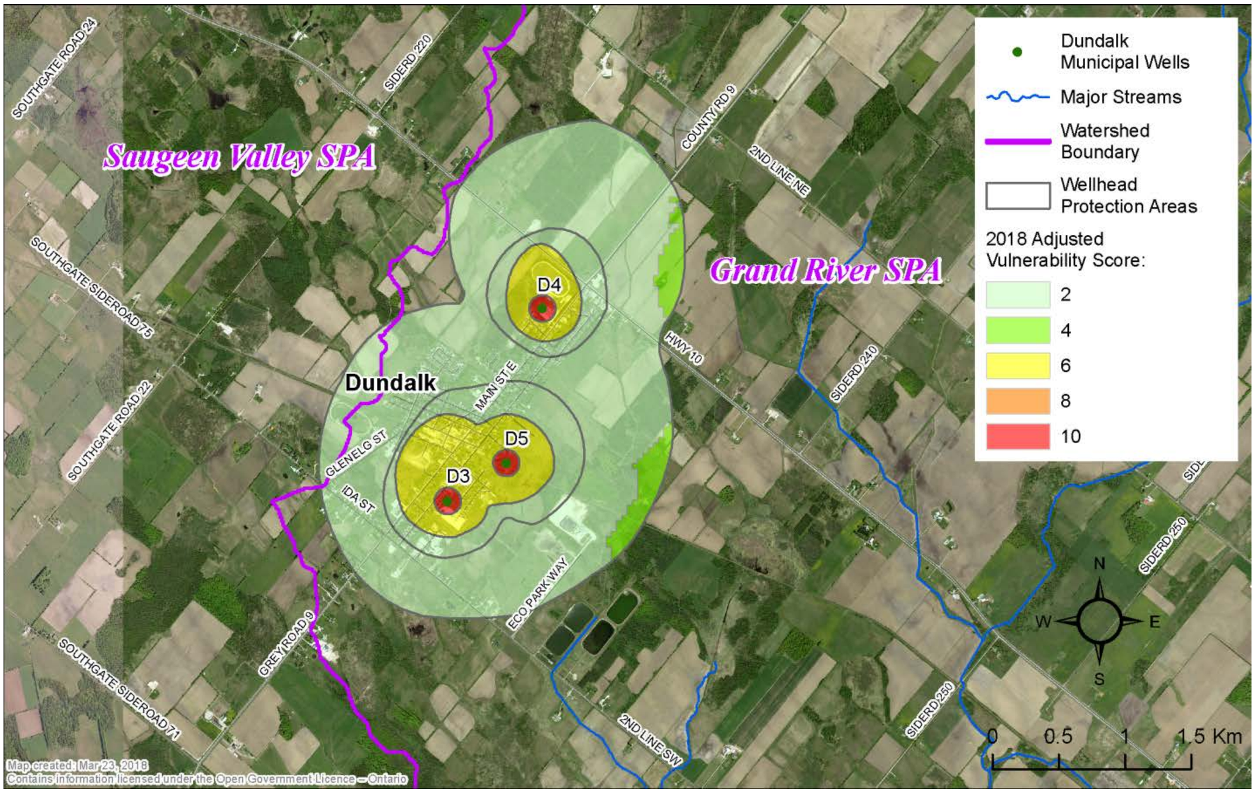

Figure 2: Vulnerability scoring within Dundalk WHPAs

Next Steps

The results of this study are recommended to be incorporated into the Draft Updated Grand River Watershed Assessment Report.

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Clean Water Act, 2006 General Regulation (O. Reg. 287/07) Amendment and New Regulation under the *Safe Drinking Water Act, 2002* Questions and Answers EBR Decision Notices: April 5, 2018

KEY MESSAGES

- Ontario is taking action to ensure safe drinking water sources through new requirements and updates to existing rules.
- The new regulation under the *Safe Drinking Water Act* will ensure protections are in place for new or expanding drinking water systems before treated water is provided to the public.
- The updates to the General regulation under *Clean Water Act* will ensure source protection plans are kept up to date, reduce administrative burdens, clarify requirements for amendments that deal with new or alterations to existing municipal drinking water systems and add pipelines as a new threat of provincial interest.
- The new regulation and changes take effect on July 1, 2018.

Q1. What's the news?

The Ministry of the Environment and Climate Change (ministry) has established a new regulation under the *Safe Drinking Water Act* to ensure sources of drinking water for new or expanding municipal drinking water systems are protected before treated water is provided to the public. The ministry also made changes to the General regulation (O. Reg. 287/07) under the *Clean Water Act* to improve how source protection plans are kept up to date and relevant.

Q2. Why did the ministry make regulatory changes?

The ministry is committed to continuous improvement of the source water protection framework and to ensure that source protection plans remain relevant and up to date. Regulatory changes were made to ensure that new or expanding municipal residential drinking water systems within source protection areas are protected by source protection plans before treated water is provided to the public. The changes also address implementation challenges, reduce burden and improve transparency for some additional types of administrative amendments and also improve consistency in protecting drinking water sources from liquid hydrocarbon pipelines.

Q3. What are the details of the regulatory changes?

New Regulation under the *Safe Drinking Water Act*:

We learned through the first round of source protection planning that it was not always clear when and how a future source of drinking water should be protected. The regulation under the *Safe Drinking Water Act* is intended to address this ambiguity and ensure that new and expanding municipal residential drinking water systems within source protection areas are proactively included in source protection plans before treated water is provided to the public. By working together, drinking water system owners and source protection authorities can ensure plans are updated in a timely manner.

The regulation made under the *Safe Drinking Water Act* requires that, prior to an application being submitted for a drinking water works permit for new or expanding municipal residential drinking water wells or intakes, the owner of the system ensures the technical work necessary under the *Clean Water Act* to identify vulnerable areas has been completed. When submitting an application for the drinking water works permit the system owner will be required to include a notice from the source protection authority. The requirements of that notice are set out in the *Clean Water Act* regulatory amendments.

In addition, the regulation requires that a condition be included within the drinking water works permit or municipal drinking water license specifying that drinking water will not be supplied to users of the new or expanding system until the amended source protection plan is approved. This provision works in tandem with the amendment to the General regulation (O.Reg.287/07) under the *Clean Water Act*, which ensures that source protection authorities initiate work to update the source protection plans when vulnerable areas are provided for these systems. Under the *Clean Water Act* regulation, when a source protection authority issues the notice needed for a drinking water works permit application, the source protection authority must confirm they are satisfied that the necessary wellhead protection areas or intake protection zones have been identified and provide details on how the plan will be updated.

Together these changes will help ensure that source protection plans are updated, putting environmental protections in place prior to treated water being provided to the public. The regulation does not apply in emergencies: when an application for a drinking water works permit is being made to alleviate an immediate drinking water health hazard or is subject to emergency exceptions under the *Environmental Assessment Act*.

This approach also recognizes that municipalities should be building the costs of source protection planning into the cost of a new or expanding drinking water system where possible. There are a number of options for municipalities to recover these costs as set out in Question 8. In addition, the province continues to fund source protection authorities to support the implementation of this program and they will work with municipalities to support technical work and policy development.

Amendments to the General Regulation (O.Reg. 287/07) under the Clean Water Act:

Plan Amendments: When source protection plans require amendments they must be consulted on and submitted to the Minister for approval unless they qualify as a typographical or other administrative amendment. The regulatory changes allow for additional types of amendments to qualify as administrative and exempt source protection authorities from the requirement to consult on and submit these types of amendments to the ministry for approval.

The two additional types of administrative amendments are those that account for:

- properly decommissioned wells or surface water intakes, and
- changes the province has made to the terminology in the Tables of Drinking Water Threats.

Amendments to Incorporate New or Expanding Systems: Additional amendments made to the General regulation under the *Clean Water Act* work in tandem with the new regulation under the *Safe Drinking Water Act*. When the source protection authority receives notice of a system owner's intent to establish or expand a drinking water system, they are required to issue a notice to the owner when they have, and are satisfied with, the necessary vulnerable area information. The regulation requires the notice provided to the owner also identify any necessary source protection plan amendments, the timing for such amendments, and if any of the amendments have been or will be implemented as a result of a source protection committee updating the plan as a result of a comprehensive review under section 36 of the *Clean Water Act*.

Prescribed Threats: When developing assessment reports all source protection committees were required to identify areas where prescribed threats pose a risk to drinking water. They were also allowed to seek approval to include local activities of concern within their communities ("local threats"). Liquid hydrocarbon pipelines were included as local threats by 5 local source protection committees, leading to an inconsistent approach across the province. The ministry heard that this activity should be evaluated consistently. In response to this, the ministry amended the General regulation to include the establishment and operation of liquid hydrocarbon pipelines on the list of prescribed drinking water threats, putting requirements in place for source protection plan policies to be developed where pipelines could pose a significant risk to drinking water sources.

Q4. What pipelines will be captured in the amended regulation and changes to the technical rules?

The amended regulation under the *Clean Water Act* will primarily capture large pipelines that are designated for transmitting or distributing liquid hydrocarbons to terminals and distribution centres. The pipeline circumstances added to the Tables of Drinking Water Threats do not capture pipelines operated by the Ministry of Natural Resources and Forestry as defined in the *Oil, Gas and Salt Resources Act*, however, this may be re-evaluated in the future.

Q5. What kind of protection plan policies could be included in local plans to address pipelines, now that they are included as a prescribed threat?

With the addition of pipelines to the list of prescribed threats in the General regulation, additional areas of the province may be subject to policies addressing pipelines. Existing policies for pipelines focused on spills prevention, emergency preparedness, education and good planning, and were not legally binding on pipeline operators or owners. These approaches have been successful in improving spills response preparedness and the consideration of vulnerable areas by pipeline companies and at the Ontario and National Energy Boards; it makes sense that similar policies be included in other source protection plans. New pipeline policies will provide consistent environmental protection of drinking water sources across all source protection areas.

The regulation includes an exemption from including pipeline policies where there is no reasonable prospect of a pipeline being constructed (for example in a vulnerable area that is already fully developed such that a new pipeline could not be extended through that zone).

Q6. Do these regulatory changes ensure transparency and accountability when plan amendments are made?

Yes, new measures included in the General regulation for administrative amendments ensure notification is provided to the ministry and others responsible for implementing plan policies. A requirement was also included to ensure that the Explanatory Document developed by source protection committees and authorities includes any rationale used in making decisions not to include policies to address future significant drinking water threats such as pipelines.

Q7. Why is water quantity work not required as part of the new regulatory requirements?

Our expectation is that if a municipality has made a decision to establish a new drinking water system, or expand an existing one, that they have looked at whether there is sufficient water in the area to support that system. In fact, existing watershed and sub-watershed scale water budgets have already been completed for all source protection areas and this information can be used by municipalities as they make decisions on where to access sources of drinking water for growth.

When municipalities are considering new or expanded sources of drinking water in areas where water quantity may be stressed in the future, a water quantity risk assessment (water budget) will be required. These can be completed during comprehensive assessment report and source protection plan reviews under section 36 of the *Clean Water Act*. As such, specific updates to water quantity assessments are not required within the regulatory changes. Assessment reports should instead include a workplan to identify when and how any necessary water quantity assessments will proceed where the work will not be completed at the time of source protection plan amendments.

Where a municipality and source protection authority choose to undertake water quantity risk assessments (water budgets) in advance of the application being submitted for a drinking water works permit under the *Safe Drinking Water Act*, the work should be included in the amended source protection plan.

Q8. How can municipalities recover the costs associated with source protection?

Source protection planning is an important and necessary part of developing new or expanding drinking water systems. Through Ontario’s investment of over $270 million we have built a foundation of watershed science that can be used when undertaking technical work to identify wellhead protection areas or intake protection zones for new or expanding drinking water systems. This will reduce the overall costs of source protection and the cost for any new technical work should be factored into the costs associated with system expansion or development. Municipalities have various options available to them to recover costs including the use of development charges where new or expanded systems are needed to support growth or through their water rates when systems are being developed to support established areas.

In some areas, as development is being established, private companies construct drinking water systems that will be assumed by the municipality at some time in the future. When these systems are assumed by the municipality, they will be subject to the *Clean Water Act.* Where drinking water works permit applications are being made, municipalities will be responsible for ensuring technical work is completed so that local source protection authorities can add them into the local source protection plan. Given this, municipalities may want to consider putting in place requirements that developers undertake the required source protection technical work before the municipality assumes the system.

Where the municipality cannot recover costs through development charges, they may wish to determine their eligibility under the Ontario Community Infrastructure Fund. This fund is generally to help cover costs associated with capital infrastructure expenditures for small, rural and northern municipalities. The ministry will also continue to work to provide funding for small rural municipalities where necessary.