Master Plans for
Urban Water Infrastructure in
The City of Vaughan

City-Wide Water & Wastewater Master Plan Class EA

APPENDIX F
Water Distribution System Modelling Technical Memorandum

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The MUNICIPAL INFRASTRUCTURE Group Ltd.

Technical Memorandum

File: **10010**

Date: **10 October 2013**

From: **Fabian Papa**, Fabian Papa & Partners Inc.
Kevin Brown & Matt Fisher, The Municipal Infrastructure Group

To: **Michael Frieri, Tony Artuso & Robert Mayer**, City of Vaughan

Re: **Water Master Plan Model Summary**
City-Wide Water & Wastewater Master Plan

This technical memorandum documents the methodology used and assumptions made in developing and employing the hydraulic model of the City's water distribution system for purposes of this Master Plan.

MODEL DEVELOPMENT

The City provided the consulting team several separate WaterCAD models representing different pressure districts within the City's distribution system which were subsequently converted and consolidated into a single City-wide steady-state model using InfoWater[1]. For purposes of master planning, it was determined that a steady-state model would produce the required results and provide the City with an easy-to-use and easy-to-maintain model to work with.

To convert the existing WaterCAD models into a comprehensive InfoWater model, the base scenario for each WaterCAD model was exported to EPANET and subsequently imported into the new City-wide InfoWater model. Initial clean-up of the newly assembled model was largely based on GIS data and mapping provided by the City and included the addition of newly installed watermains (to the extent practical) which were not yet captured in the City's model as well as a reconciliation of differences in model element (e.g., pipe, node) information between the model and other sources of information and the elimination of duplicated data as a result of the multiple imports of the previously separated pressure districts into the new model.

Following initial testing of the model and the identification of information gaps, three extensive working sessions were held at the City's offices and included members of the consulting team as well as staff from the City's Development/ Transportation Engineering and Public Works Departments to review the model in detail and to specifically address important components of the model, such as connections to Regional infrastructure as well as general operation of the system including PRV settings, amongst others.

The York Region and City of Toronto infrastructure elements that were generally included with the existing WaterCAD models were largely retained in the new, City-wide InfoWater model. Based on historical as well as more recent pressure recording information[2], as well as information relating to the operation of the system from other sources (e.g., Region of York), certain connections to external infrastructure and other boundary conditions were modeled as fixed-head reservoirs[2] where determined appropriate for the nature of this study. In some cases, where the existing WaterCAD models contained pumps, these were deactivated or deleted and replaced with fixed-head reservoir connections where determined appropriate in order to provide appropriate confidence with the modelling results. It is noted that many of the pump systems to which the City's distribution system is connected are owned and operated by others and, accordingly, modelling these systems accurately is often challenged as a result of imperfect information. Using measured and known hydraulic grade elevations removes much of this uncertainty.

[1] At the outset of the project, an analysis and evaluation of alternative software platforms for this purpose was prepared and the City elected to change their current water modelling software system to InfoWater, in part to maintain compatibility with the Region's hydraulic modelling which also uses this software.
[2] Refer to Technical Memorandum on Water Distribution System Pressure Monitoring dated 12 September 2012.

MODELLING SCENARIOS

The City-wide hydraulic model employed several scenarios which accounted for different loading conditions resulting from projected changes in population from the current period (taken to be 2006 for this assignment) to the end of the planning horizon (2031)[3], as well as a result of revisions made to the design criteria[4]. Also, different pipe sets were used similarly representing current (2006) and 2031 conditions, the latter of which were developed during the course of identifying and evaluating alternatives in the Master Plan study. Numerous combinations of these conditions were reviewed iteratively and the modelling results for the following scenarios are discussed further herein:

Model Year	Pipe Set	Demand Condition	Design Criteria	See Results
2006	Existing	Average Day	Existing (pre-2012)	Figure 1
2006	Existing	Peak Hour	Existing (pre-2012)	Figure 4
2006	Existing	Maximum Day + Fire	Existing (pre-2012)	Figure 7
2031	Proposed	Average Day	Existing (pre-2012)	Figure 2
2031	Proposed	Peak Hour	Existing (pre-2012)	Figure 5
2031	Proposed	Average Day	New	Figure 3
2031	Proposed	Peak Hour	New	Figure 6
2031	Proposed	Maximum Day + Fire	New	Figure 8

DISCUSSION OF RESULTS

Result Presentation

The results for each of the scenarios are discussed briefly herein are presented graphically in the figures as noted in the table above using the following legend:

Average Day & Peak Hour Demand Scenarios		**Maximum Daily Demand + Fire Flow Scenarios**		Pressure Districts	
●	< 140 kPa (<20 psi)	●	< 30 L/s		PD4
●	140 kPa – 275 kPa (20-40 psi)	●	30 L/s <> 90 L/s		PD5
○	275 kPa – 350 kPa (40-50 psi)	○	90 L/s <> 150 L/s		PD6
●	350 kPa – 450 kPa (50-65 psi)	●	150 L/s <> 250 L/s		PD7
●	450 kPa – 550 kPa (65-80 psi)	●	250 L/s <> 400 L/s		PD8
●	550 kPa – 700 kPa (80-100 psi)		*not assigned*		PD9
●	> 750 kPa (>100 psi)	●	> 400 L/s		PD-KN

[3] Refer to Technical Memorandum on Planning Projections dated 09 March 2012.
[4] Refer to Technical Memorandum on Design Criteria dated 09 March 2012.

Average Day Demand Conditions

In general, there is very little change in system performance, as measured using pressures, between the scenarios presented. As would be expected, for the case where the design criteria is unchanged from the existing (i.e., pre-2012) the increased population in 2031 places additional demand on the system resulting in pressures to be lower than the 2006 condition, however, with the application of the new design criteria, these pressures return to their 2006 levels. This is the expected result due to the change in design criteria.

While most of the system is expected to operate within normal and acceptable pressure ranges, a localized area near the intersection of Yonge and Centre Streets is expected to experience high pressures. This situation applies to both current and future conditions and is a result of the local elevations of this area which is within the PD6 pressure zone.

Peak Hour Demand Conditions

Similar to the above discussion, there are no significant concerns with respect to the proposed future performance of the system under peak hour demand conditions. The impact of the increased population alone results in somewhat reduced pressures, an effect which is largely offset by the application of the new design criteria. The comments related to the localized area at Yonge and Centre Streets also apply here.

Maximum Day + Fire Demand Condition

The results for this demand condition, represented as available fire flow while maintaining a minimum system pressure of 140 kPa (20 psi), show that there is generally very little difference between current (2006) and future (2031) conditions. Although there are several nodes which may give rise to some concern, it is important to note that these are largely located at system extremities or in areas of high elevation for which more specific risk and performance assessments are warranted. That is, these are not systemic issues which require attention at the Master Planning level in many cases. Nevertheless, some of the Master Plan recommendations will help to specifically address some of these concerns, namely the following projects[5]:

- **W1(B) – PD8 East Improvements**
  This project recognizes that there are several nodes in this pressure district which are expected to provide relatively low fire flows and for which, in addition to hydraulic connectivity improvements to Region infrastructure, specific study with respect to fire protection is recommended. Further, this work should entail a risk assessment based on the specific conditions as the basis for determining what, if any, additional local improvements are appropriate to consider.

- **W6 – Woodbridge Expansion Area PD6 Watermain Connection**
  W8 – Major Mackenzie Drive PD6 Watermain
  The lands at the northerly extent of the Woodbridge Expansion Area and south Kleinburg are located at an extremity of the PD6 system and these projects will help improve the availability of water and pressure under a wider range of conditions.

- **W10 – PD5-East**
  This project recognizes that these lands are relatively high in relation to the PD5 service elevation range and, as such, experience relatively low, although still acceptable, pressures and accordingly somewhat reduced ability to maintain residual pressures during fire flow or other emergency conditions. This project envisions further detailed study to support which improvements, if any, would be appropriate for the City to consider.

- **W12 – Realignment of PD4/PD5 Zone Boundary on Kipling Avenue**
  This area is located at an extremity of the PD4 system and is located at relatively high elevation. Accordingly, pressures under normal operating conditions, while acceptable, are relatively low and are expected to produce generally low fire flows while maintaining minimum system pressures. Additional monitoring and study of this area may result in the realignment of the zone boundary to move this area into the adjacent PD5 pressure zone.

[5] Refer to Memorandum on Update to Water & Wastewater Projects and Cost Estimates dated 26 June 2012 and main body of Master Plan project report.

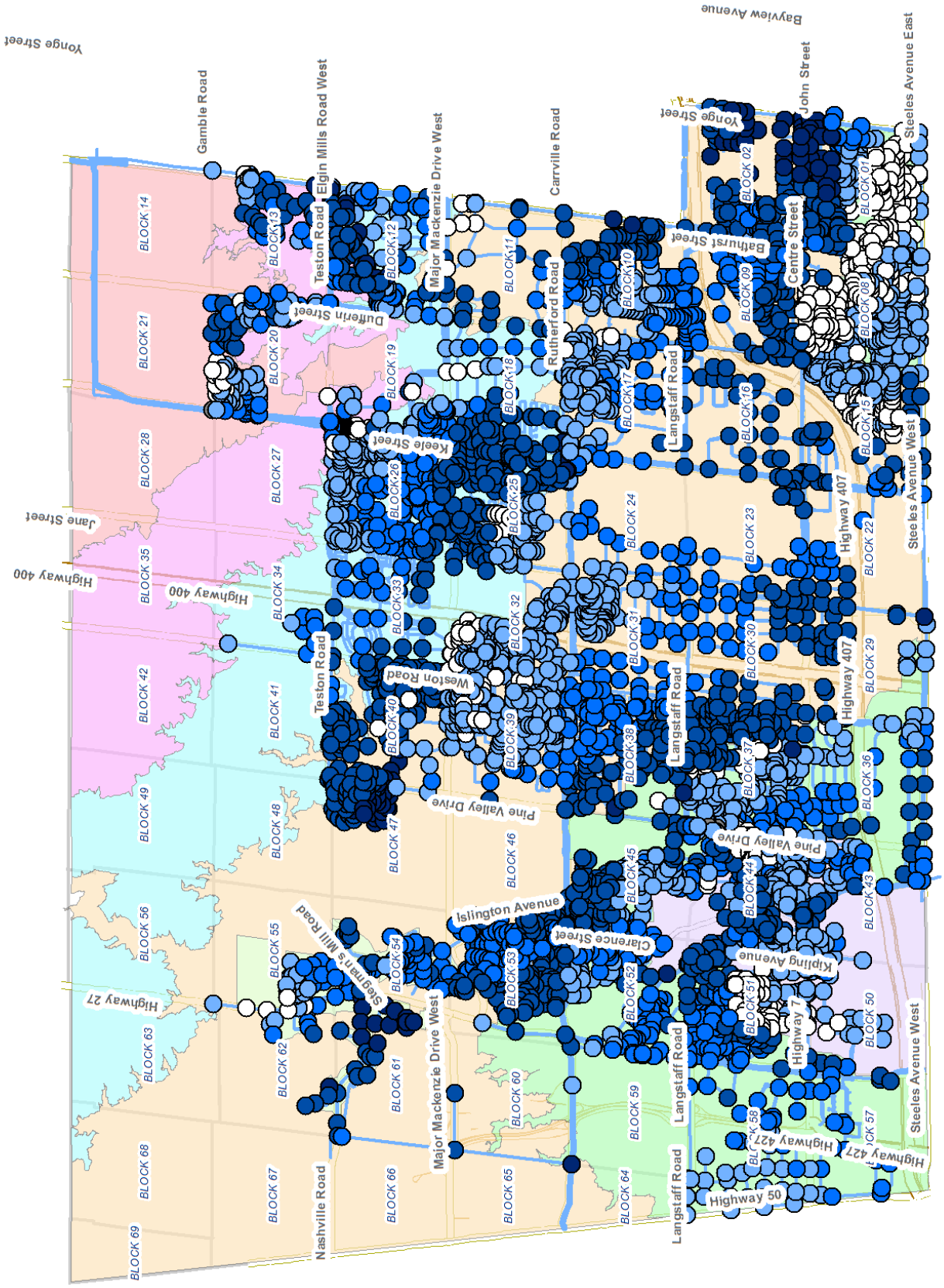

Figure 1 Modelling Results for: 2006 Average Day Demand, Existing Design Criteria

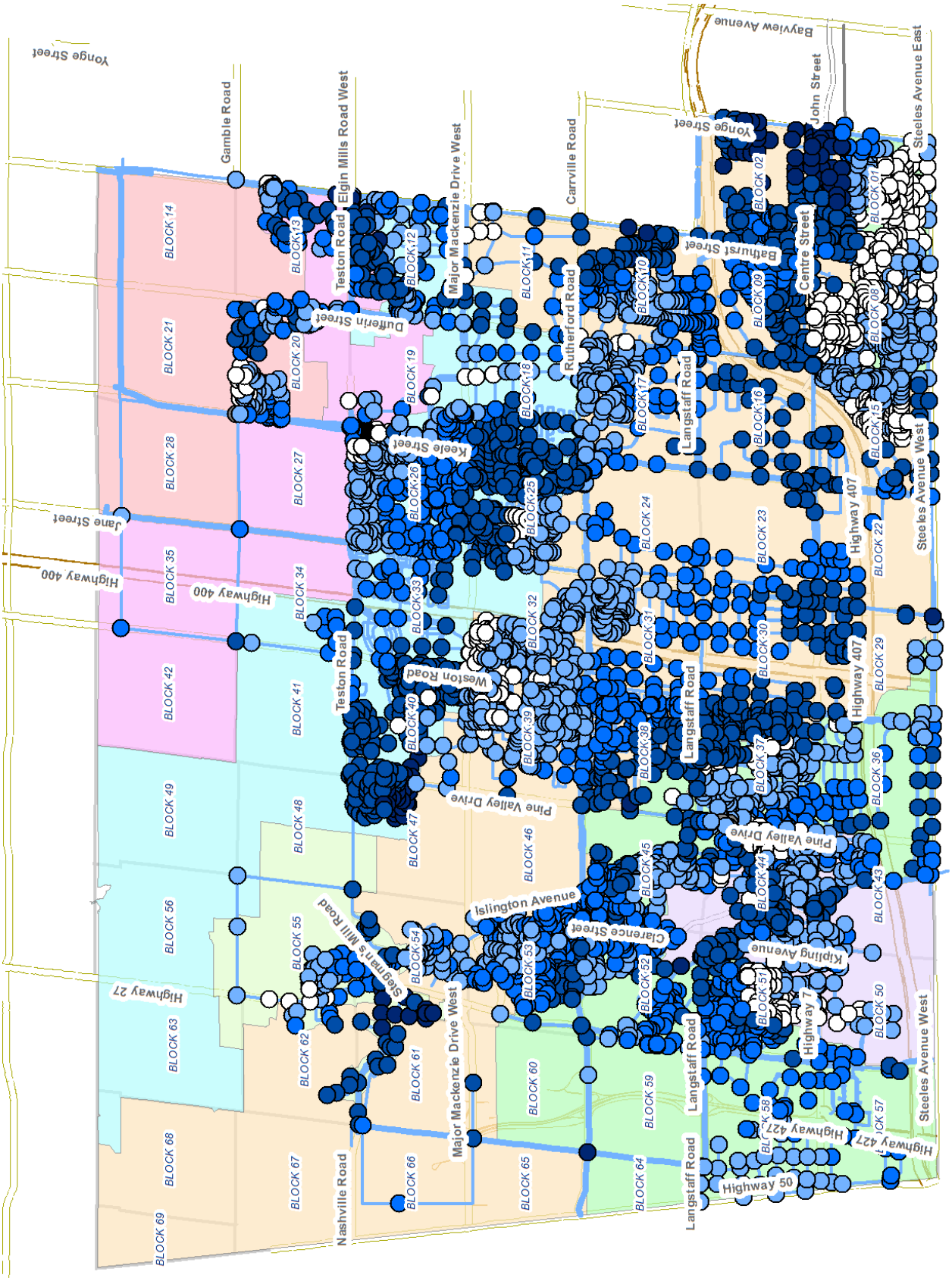

Figure 2 Modelling Results for: 2031 Average Day Demand, Existing Design Criteria

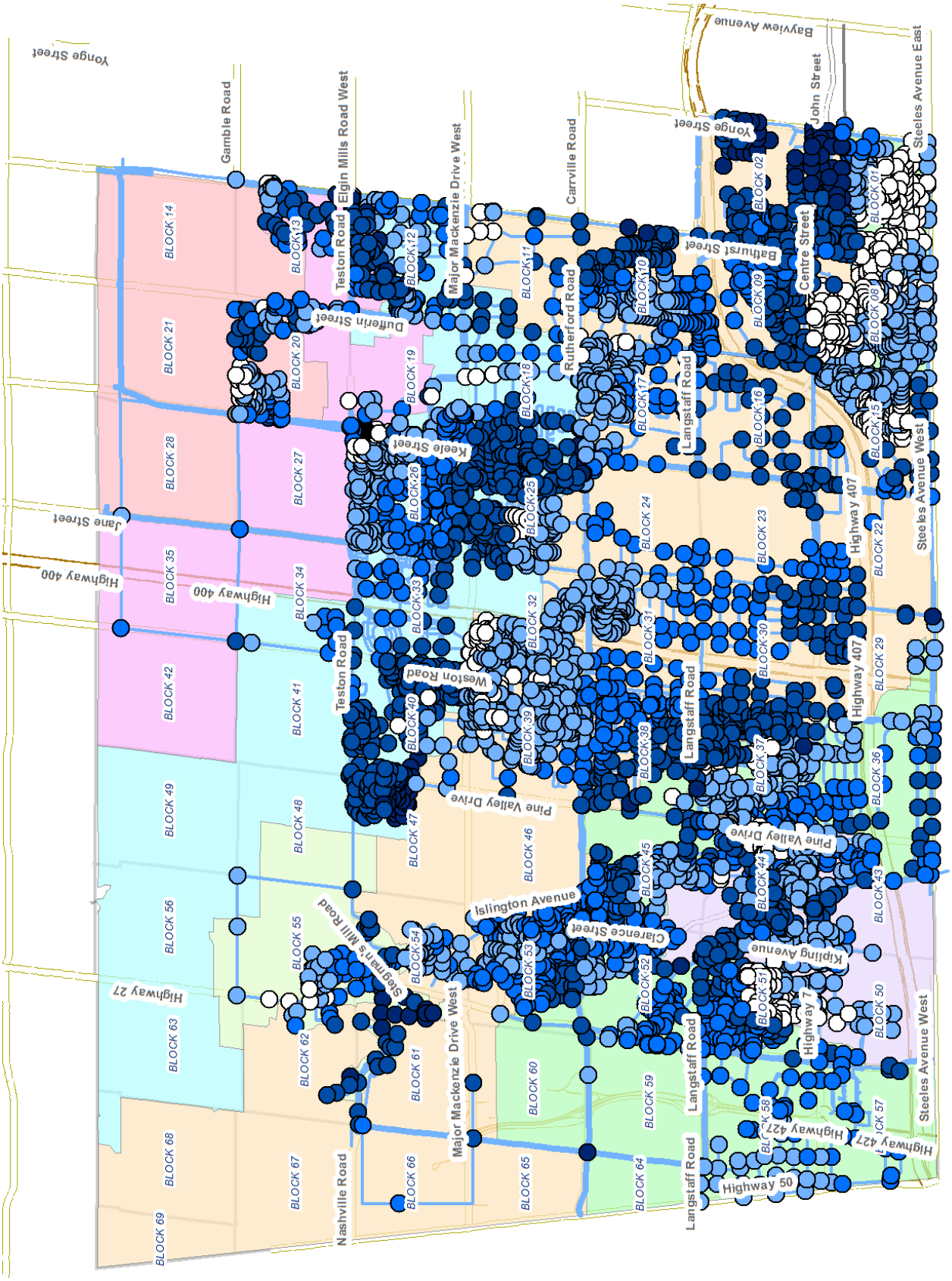

Figure 3 Modelling Results for: 2031 Average Day Demand, New Design Criteria

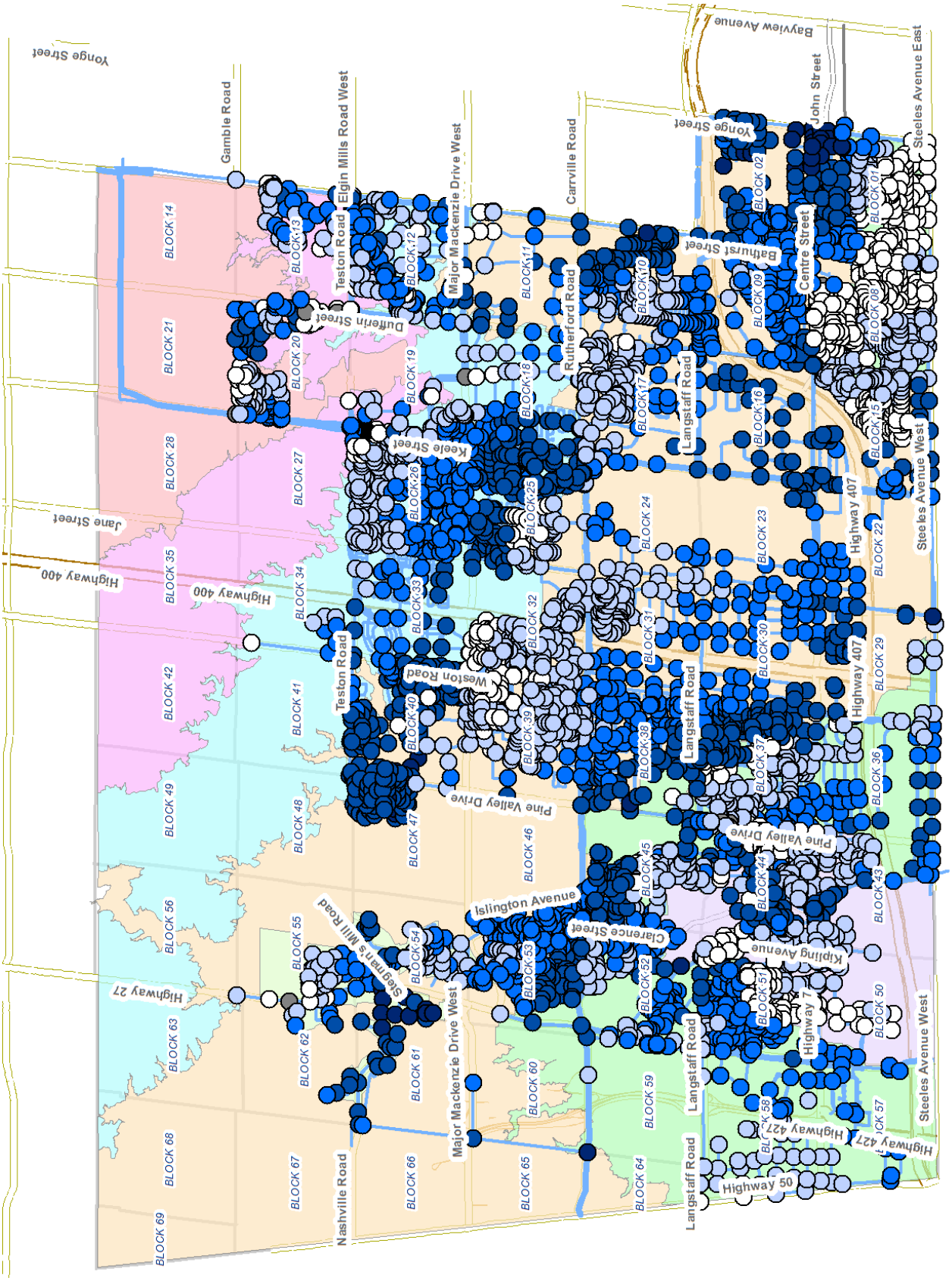

Figure 4 Modelling Results for: 2006 Peak Hour Demand, Existing Design Criteria

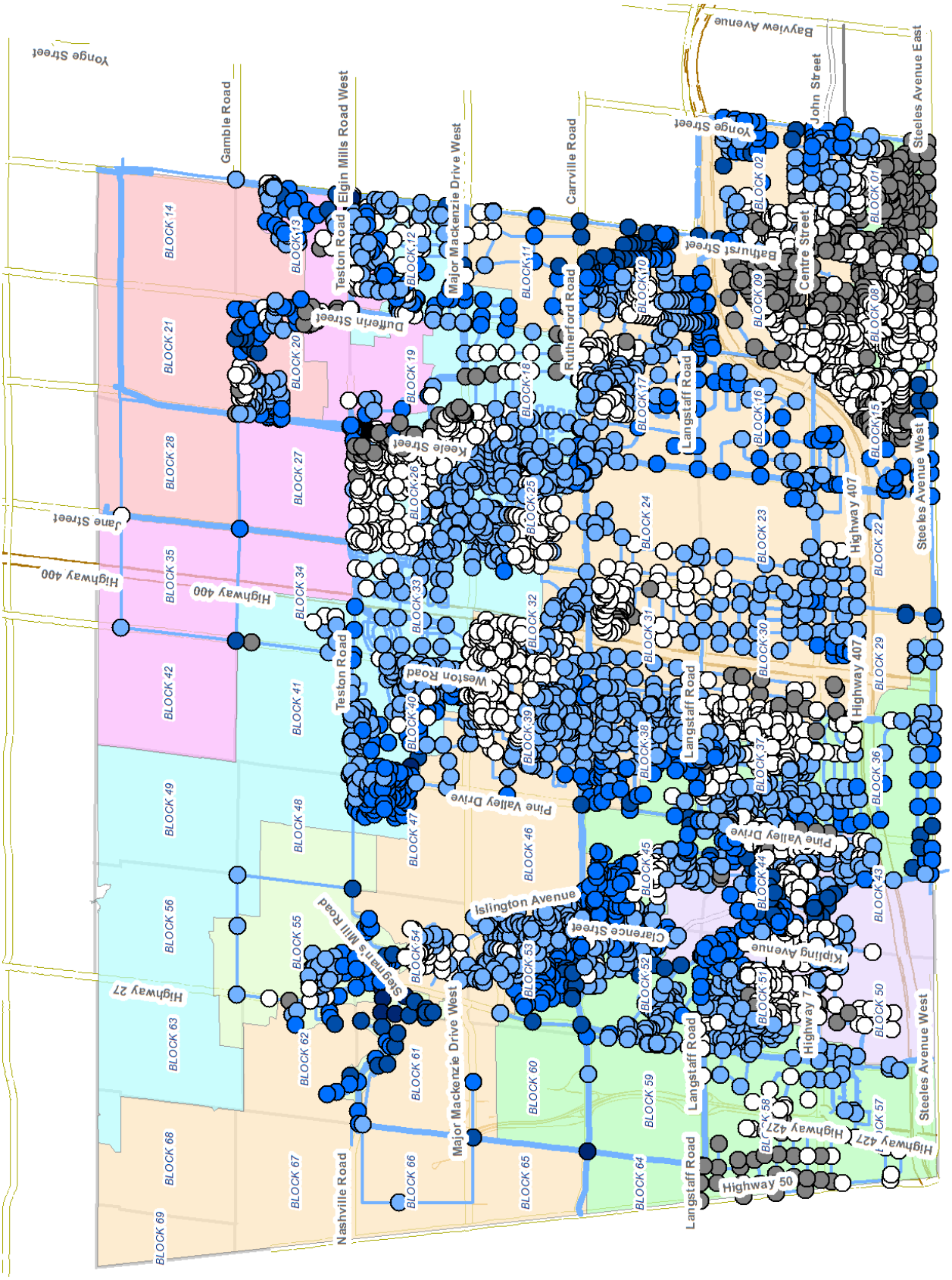

Figure 5 Modelling Results for: 2031 Peak Hour Demand, Existing Design Criteria

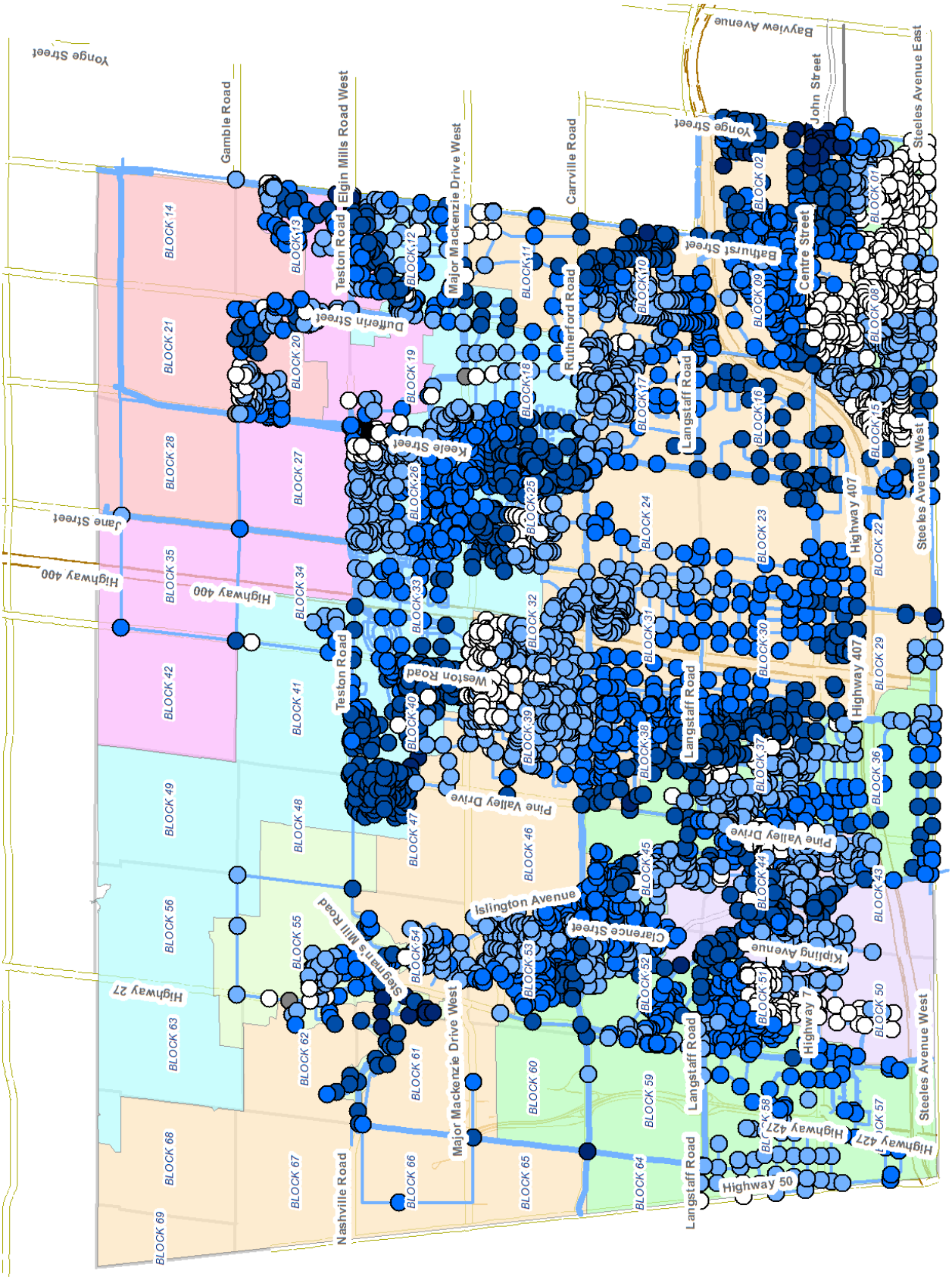

Figure 6 Modelling Results for: 2031 Peak Hour Demand, New Design Criteria

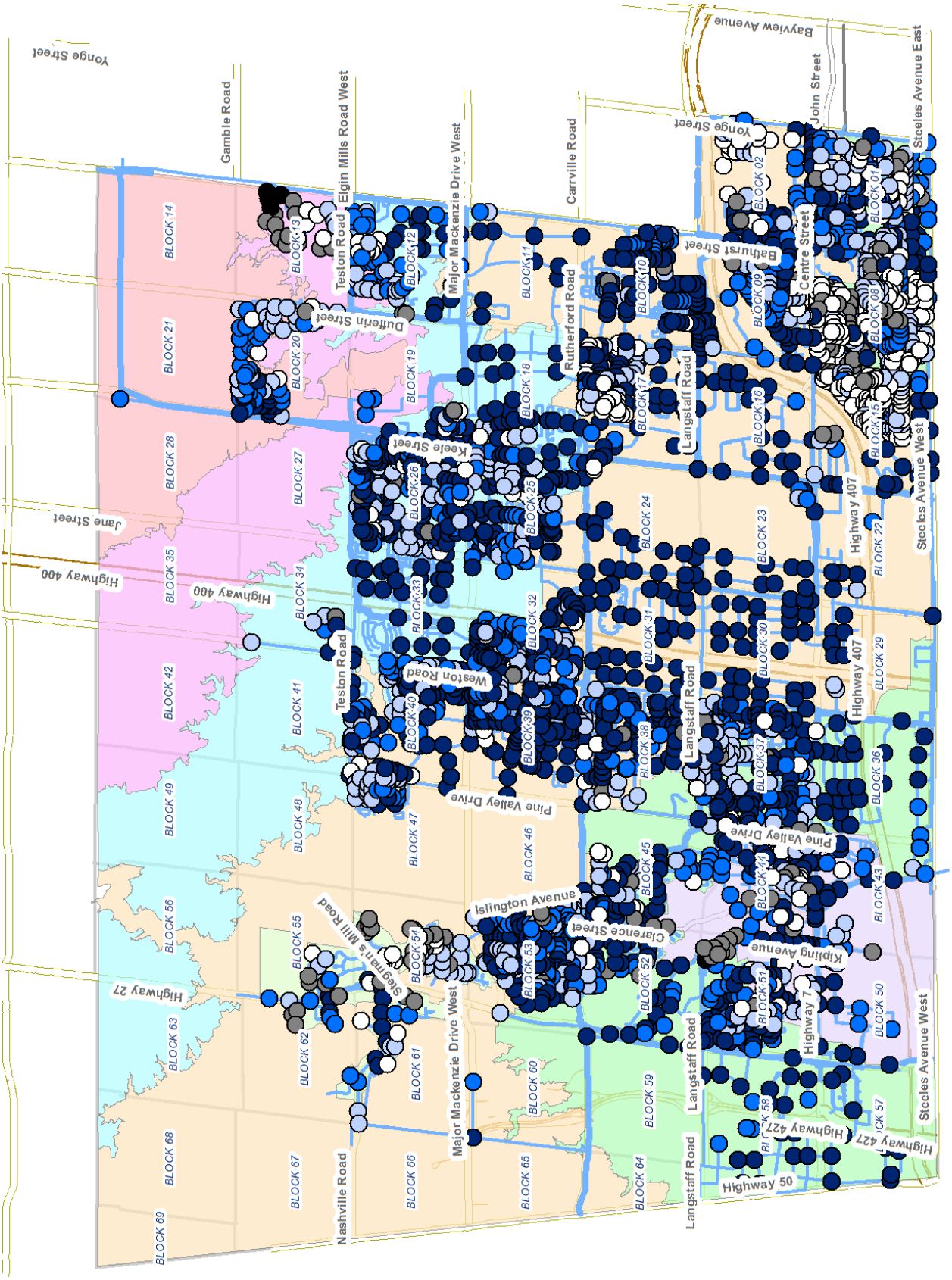

Figure 7 Modelling Results for: 2006 Maximum Day + Fire Demand, Existing Design Criteria

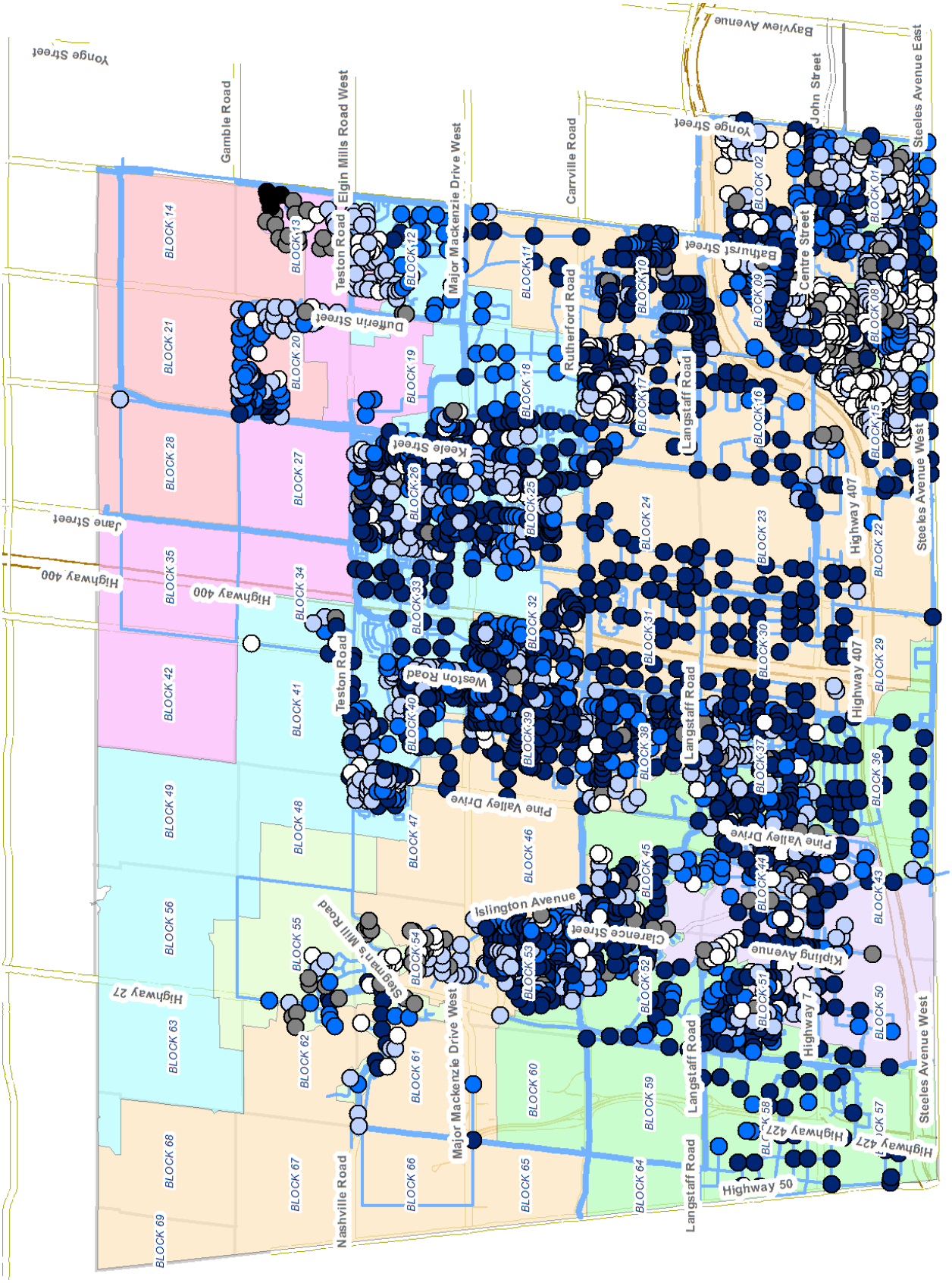

Figure 8 Modelling Results for: 2031 Maximum Day + Fire Demand, New Design Criteria