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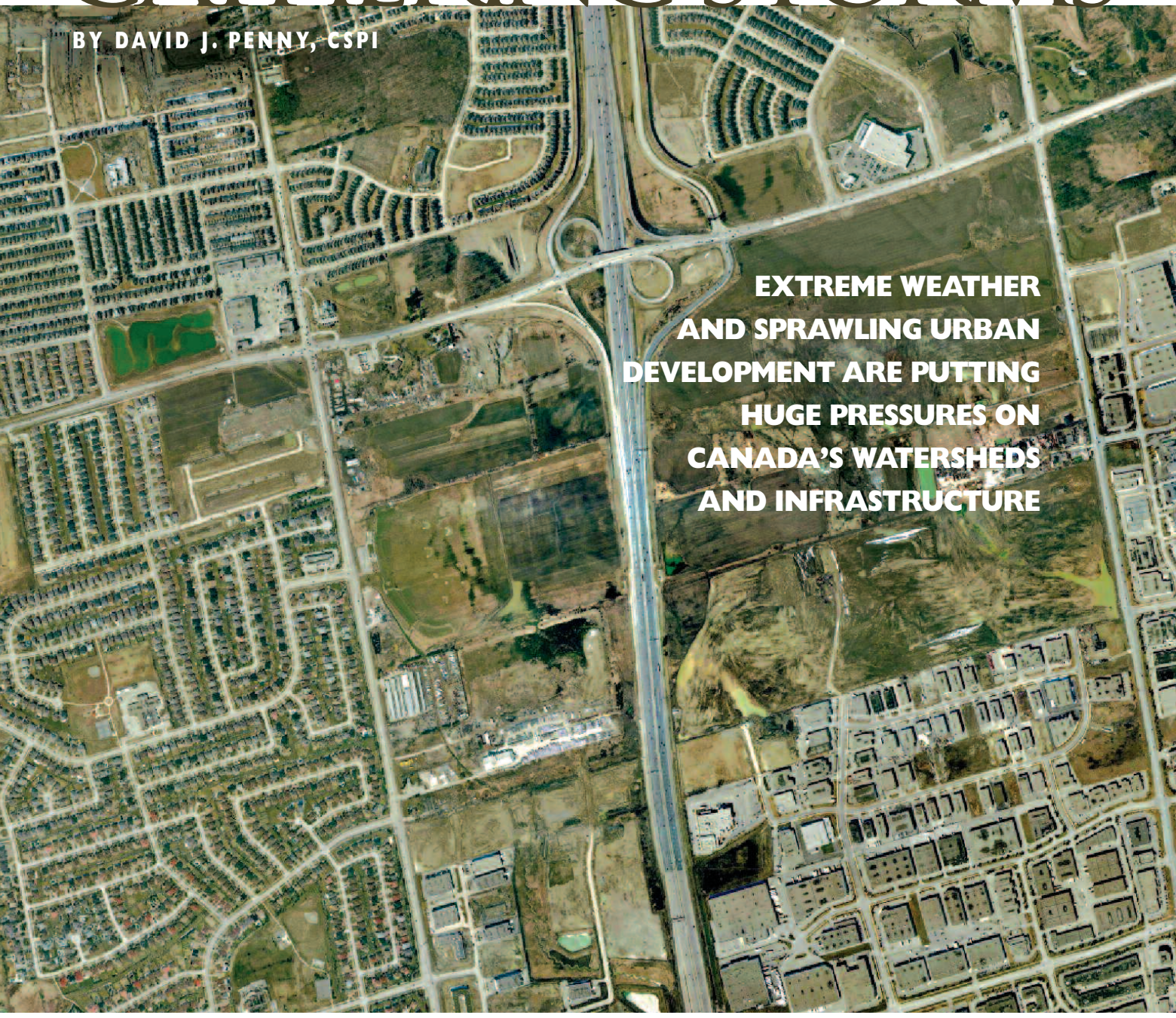
BY DAVID J. PENNY, CSPI



EXTREME WEATHER AND SPRAWLING URBAN DEVELOPMENT ARE PUTTING HUGE PRESSURES ON CANADA'S WATERSHEDS AND INFRASTRUCTURE

It is Monday, March 13, 2006 and I am driving on Highway 407 across the top of Toronto. My mission is to photograph the new 11.5-metre span, deep corrugation, steel arch culvert at Finch Avenue and Black Creek. The bridge has been open to traffic since January 20, exactly five months after this major arterial road was washed out in a violent summer storm. Today's gentle rain and warm temperature has the radio warning parents to keep children away from streams that are bursting with snow melt. Stormwater detention ponds along the new eight-lane toll road are filled to their overflow risers. What a beautiful day to be in the drainage business.

As I descend into the Black Creek valley I pass the Highway 400 interchange, hectares of ramps and bridges that connect to the 16-lane superhighway to the north. A 10-kilometre trip up the highway through Vaughan takes you to the headwaters. You pass industrial developments, vast shopping complexes, Canada's Wonderland and new residential subdivisions. Many are still under construction with topsoil scraped away for the installation of sewers, water mains, roads and stormwater ponds.

It wasn't like this on October 15, 1954. Black Creek north of Finch Avenue was then a small wooded stream flowing through farmland. It was on this date that Hurricane Hazel dumped 285 mm of rain on the already saturated watershed in a 48 hour period. The results were devastating. "Bridges and streets were washed out, homes and trailers were washed into Lake Ontario. Thousands were left homeless and 81 people were killed" (www.hurricanehazel.ca).

This one event changed the way stormwater is managed in Ontario. Regional conservation authorities were established to manage entire watersheds. In the Toronto area, with the guidance of the Toronto Region Conservation Authority (TRCA) an elaborate infrastructure for storm management has been constructed. TRCA headquarters are located immediately upstream from today's destination.

Traditional drainage infrastructure in the form of storm sewers, ditches and channels is designed to handle minor storm events, which occur on a regular basis. Statistically the worst of these may occur every two to five years. More serious storms that may happen every 50 to 100 years are too large for the minor system and must be handled by a major system. Major storm flows, if not detained in lakes, natural landforms or behind flood control dams in large reservoirs, flow overland in right-of-ways, roadways and river channels. Bridges, dykes and other structures are designed to direct and contain these flows. Hurricane Hazel set the benchmark in Ontario as the 100-year storm.

Then almost a year ago, on Friday, August 19, 2005 a violent summer storm tracked along the same route that I am driving this morning. It dropped as much as 123 mm of rain in less than three hours. This is almost half the water that Hazel produced in two days. Environment Canada and TRCA were able to collect a large amount of data about last summer's storm and are working on a report that will help engineers to understand its dynamics. A storm that started at 3:55 p.m. had major intersections in Vaughan under metres of water throughout the rush hour. The debris-choked and swollen creek proved to be too powerful for the embankment and culvert at the Finch Avenue outlet. A resident in a nearby apartment building snapped real-time photos of the washout, which were soon on internet sites. The culvert had been built in a different era in response to Hazel. In 50 years the country road had been widened, buried deeper, filled with the pipes and cables that make up urban infrastructure, and paved several times. Much had been done to accommodate changing traffic rates and volumes but relatively little was done to accommodate changes in stream flow related to urban growth.

In "The Changing Climate and Increasing Vulnerability of Infrastructure," Heather Auld and Don MacIver of Environment Canada (Occasional Paper, 3 January 2005) explain why we will see more infrastructure failures in the future. There is a definite trend in Canada to warmer, wetter and more extreme weather. This weather will bring the obvious changes to run-off rates and volumes due to increased rainfall and snow pack, but also it will bring more subtle changes related to cause and effect. As an example, climate change is largely responsible for the Pine Beetle devastation of British Columbia forests; the deforestation in turn results in less moisture returned to the atmosphere and therefore increased run-off. "Full to Bursting," (*The Economist,* February 2006) reports on research indicating that trees in carbon dioxide rich atmospheres, influenced by industry and forest fires, have to work less hard to complete the photosynthesis process. This laziness means the trees release less water back into the air, increasing local runoff and changing weather patterns down-

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Right: Highway 400 & Rutherford Road north of Toronto in 1983. Opposite left: same area in 2002; fields make way for development.

Photos this page and opposite: Toronto Region Conservation Authority

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Above left: Black Creek at Finch Avenue on March 13, 2006; the water is high and flowing with natural debris. Above right: Black Creek four days later; water levels rise and drop dramatically in urban areas.

wind. Removing vegetative cover through urbanization eliminates opportunities to manage stormwater runoff. Unlike natural vegetation, paved surfaces have little ability to absorb and hold water. Pollution in the air and water continues to attack infrastructure, as will freeze-thaw cycles, dry-wet cycles and wind. With all these cumulative effects, we can expect to see more of the violent storms and damage that we saw on August 19, and we can expect to see them more often.

Our infrastructure is designed based on assumptions of reasonable risk. We assume that certain storms will statistically occur every 100 years and when they do they will produce winds to maximum velocities and runoff at a certain rate, volume and depth. Infrastructure designed to these standards will see minimal damage, but both damage and insurance claims are greatly magnified when a storm exceeds the design limits.

As I drive I wonder about the stormwater ponds beside the highway and make a note to call a friend at the Ontario Ministry of Transportation. When I do, I learn that stormwater management is a key element of all highways designed in the province. The Ministry's "Storm Water Planning and Design Manual" issued in March 2003 considers all aspects of design in its 400-plus pages, but it is the first line of the manual that says all. "The "state-of-the-art" of stormwater management has been rapidly evolving and this manual is one step in this evolutionary process."

The August 19 storm did considerable damage throughout Vaughan and the city hired Clarifica Consulting to provide a detailed analysis. The consultants concluded that: "approximately 85% of the entire area of the city experienced 100-year storm conditions or worse." A detailed report identifies six priority projects and studies for 2006 that are a direct result of the storm and are estimated to cost $1.1 million. They include studies on stormwater management, sediment and erosion control, citywide drainage and monitoring of the sewage flow. There is also to be removal of sediment from storm ponds in various locations.

A few days after the report was completed this Febru-

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ary, the major Vaughan intersection at Jane Street and Highway 7 caved in. A large sanitary sewer that was damaged by the August flood shifted, creating a sinkhole. It was expected that the intersection would be closed for several months of expensive repairs.

As with Hurricane Hazel, major storms cause us to reflect and re-examine the infrastructure. Last August's storm in the Black Creek Watershed should get close attention as it directly affected major municipalities and agencies located within it. All these parties are involved in stormwater management but despite their following state-of-the-art best management practices, considerable damage has occurred.

In the years ahead it will be impractical simply to replace infrastructure that has proven to be inadequate in the evolving weather and drainage situation. Engineers will be challenged to optimize the balance of flow throughout watersheds and to find innovations in stormwater management and land use planning.

The multiplier effect of having small, fast draining watersheds in the form of parking lots and rooftops depositing their flow into one channel also must be addressed. Managing stormwater run-off at the source needs to become a much higher priority.

My journey continues off the 407 and south to the new Finch Avenue culvert. August flood debris still hangs on fallen trees along the creek. The muddy water is flowing fast and is near the top of bank. From my vantage point, the culvert with reinforced headwall is huge. It is many times larger than the one it replaced. The spring flood barely reaches the top of the culvert footings. It appears that it will handle all that future storms will send its way.

The culvert is, however, just one link in a complex network of stormwater management infrastructure. If stormwater management practices can evolve to detain more raindrops close to where they fall, our infrastructure may survive climate change and urbanization. As I start my return journey I am reminded of a comment by Easton Gordon, P.Eng. of the culvert designers, McCormick Rankin Corporation: "What's happening downstream? You have to ask the question." **CCE**

David J. Penny, BES, is the marketing manager of the Corrugated Steel Pipe Institute in Cambridge, Ontario. www.cspi.ca

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