Fanie Buys & Mike Aldous

The perceived economic impact of the City of Johannesburg's storm water attenuation policy on private property developers

Peer reviewed

Abstract

Over recent years storm water attenuation policy has become a contentious issue for the property development community, both locally and internationally. Increased urbanisation has forced municipal authorities to reconsider the role of storm water management in an evolving urban landscape. It is within this context that the legislative support and municipal policy for storm water management in the City of Johannesburg (CoJ) has been considered, with direct regard to the perceived economic impact of storm water policy on private property developers. Factors considered included the cost, risk, and time factors of policy compliance within the development process.

Research of international policy implementation issues in countries with well-developed storm water management frameworks formed the basis for the design of a questionnaire to evaluate the response of local private property developers to the relevant issues.

Results of the research indicated that developers had a below average level of knowledge with regard to the storm water management policy of the CoJ, as well as of the underlying supporting legislation. The results of the survey further indicated that developers were strongly opposed to the loss of developable area, but indicated a limited financial impact of the current storm water attenuation policy. The risk element inherent in incorporating attenuation facilities within a development was identified as being low, with little perceived impact, while indications highlighted the inclusion of attenuation facilities as a significant contributing factor in the delay of approval and acceptance of new developments. The additional maintenance costs associated with attenuation facility inclusion were indicated to be of a low level of importance to developers.

Keywords: stormwater, economics, attenuation, pond, detention.

Prof. Fanie Buys Head of Department of Building and Quantity Surveying Nelson Mandela Metropolitan University P O Box 77000 Port Elizabeth 6031 South Africa Email: <Fanie.Buys@nmmu.ac.za>

Mike Aldous MSc BE graduate Department of Building and Quantity Surveying Nelson Mandela Metropolitan University P O Box 77000 Port Elizabeth 6031 South Africa Email: <mikea@pdna.co.za>

Abstrak

Stormwaterverminderingsbeleid het oor die afgelope jare 'n netelige saak vir die eiendomsontwikkelingsgemeenskap nasionaal en internasionaal geword. Verhoogde verstedeliking het munisipaliteitsowerhede gedwing om die rol van stormwaterbestuur in 'n groeiende stedelike omgewing te oorweeg. Dit is binne hierdie konteks dat die wetgewingsondersteuning en munisipale beleid oor stormwaterbestuur in Johannesburg oorweeg word met direkte verwysing na die oorwegende ekonomiese impak van stormwaterbeleid op privaateiendomsontwikkelaars. Faktore wat oorweeg word, sluit in: die koste, risiko, en tyd van beleidooreenkoms binne die ontwikkelingsproses.

Navorsing oor internasionale beleidsimplimentering in lande met goed ontwikkelde stormwaterbestuursraamwerke vorm die grondslag vir die ontwerp van 'n vraelys om die reaksie van plaaslike privaat eiendomsontwikkelaars oor die relevante sake te evalueer.

Resultate uit die navorsing dui aan dat ontwikkelaars 'n laer as gemiddeld kennis van stormwaterbestuursbeleid asook van die onderliggende ondersteuningswetgewing van Johannesburg gehad het. Die resultate dui ook aan dat ontwikkelaars sterk teenkanting getoon het teen die verlies van ontwikkelbare gebiede, maar dui 'n beperkte finansiële impak van die huidige stormwaterverminderingsbeleid aan. Die risiko element van die inkorporering van verminderingsfasiliteite binne 'n onwikkeling was as laag aangedui met 'n klein impak, terwyl die insluiting van verminderingsfasiliteite as 'n merkbare bydraende faktor in die vertraging om goedkeuring en aanvaarding van nuwe ontwikkelings te verkry, uitgelig is. Die addisionele instandhoudingskoste wat met ingeslote verminderingsfasiliteite geassosieer word, is aangedui om van min waarde vir ontwikkelaars te wees.

Sleutelwoorde: Stormwater, ekonomie, vermindering, dam, oponthoud.

1. Introduction

The role of the civil engineer is inextricably shaped by the changing face of urban morphology. Fulfilling roles in both private and public spheres, the engineer is compelled to find a balance between the hard sciences and economic limitations particular to each project.

The current storm water management policy adopted by the CoJ through the utilisation of storm water attenuation as a primary control mechanism forms the basis of research undertaken to explore the financial and economic implications of the storm water policy as perceived by private property developers. The research findings may sensitise built environment professionals to the perceived economic impact factors of concern to private developers enabling the adaptation and application of appropriate engineered solutions.

The relevance of the topic to the engineering community arises through the role of the consulting engineer in addressing the needs of the private developer in a cost-effective manner while satisfying legislative requirements and sustainability objectives. The task of guiding storm water management often falls to the consulting engineer, becoming implicitly faced with balancing client expectations and legislative requirements, while constrained by defined economic parameters.

The research focused on the following developer perceived impact areas of storm water policy:

- Level of policy knowledge;
- Impact on project feasibility;
- Impact on property values;
- Impact on maintenance costs;
- Impact on project delays, and
- Risk profile impact.

2. Literature review

The review of the related literature focused on fundamental storm water best management practices, key motivating factors in support of enhanced levels of storm water management, regulatory support levels, the general economic implications of storm water management, and its impact on private property developers.

2.1 An overview of storm water attenuation principles

The current storm water management policy adopted by the CoJ calls for the attenuation of storm water on- or off-site to predevelopment run-off volumes by means of the inclusion of an open air pond and controlled outlet structure for the purposes of attenuation. A further refined, but fundamentally similar approach is advocated by Brooker (2006) in the proposed Draft Catchment Management Policy (CMP) under consideration by the CoJ. Figure 1 indicates a typical 'dry' storm water pond located North of Johannesburg within a new residential development.

Figure 1: Typical open-air storm water attenuation pond in the Johannesburg area.
Source: Aldous 2007: own picture

Figure 2: Regional Ponds – Dunfermline Scotland
Source: Adapted from Apostalaki & Jefferies 2005: 9

The inclusion of an attenuation pond allows the physical alteration of the timeframe and peak discharge rate of run-off emanating from a catchment area by the incorporation of a temporary storage facility and controlled outlet. Figure 3 is a diagram indicating a typical storm water hydrograph reflecting the mitigation of the post-development peak flow by the inclusion of an attenuation pond.

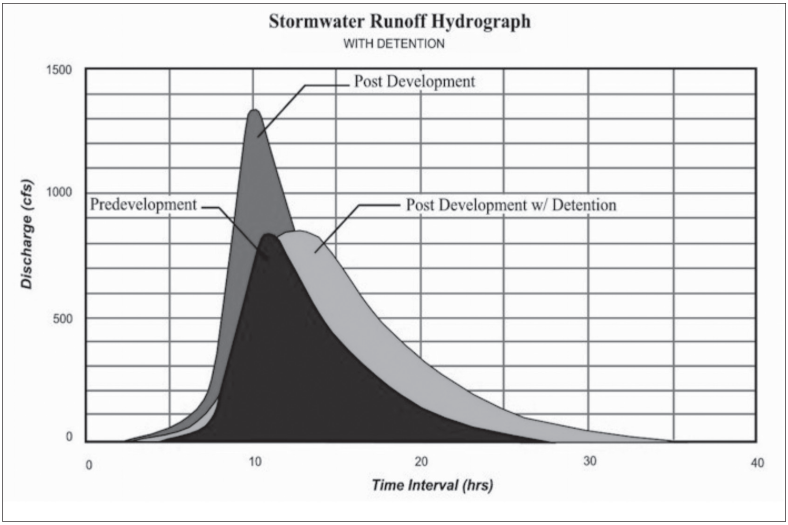

Figure 3: Typical run-off hydrograph for pre- post- and attenuated storm water flows.
Source: Adapted from Pennsylvania (United States). Department of Environmental Protection - Bureau of Watershed Management 2006: Chapter 2:8.

Pond structures in the local environment may be constructed as 'wet' ponds where a permanent pool of water is present, or alternately as a 'dry' pond that discharges completely over a delayed period subsequent to a storm event. The 'dry' pond approach is currently the more prevalent approach in the CoJ based on an analysis of aerial photography of current development nodes.

2.2 Motivating factors in support of enhanced levels of storm water management

2.2.1 Development pressure on storm water infrastructure

A global trend has emerged in pursuing "… integrated planning for sustainable management of land resources" (South Africa. Ministry of Agriculture and Land Affairs, 2001: online). The integrated approach is regarded as a response to the continued failure of conventional land use planning to provide improvements in land management. Schueler (2000) identified land use planning as a major tool in addressing the impact of development on watersheds.

Global trends in urbanisation have led to vast increases in population densities, resulting in the focused densification of relatively small areas, placing the environment under significant stress and, in turn, negatively impacting natural and engineered watercourses. The current trend in Johannesburg is towards the development of smaller erven as a direct result of urban densification policies and economic factors. Decreasing erf size has increased impermeable surfacing coverage, reducing infiltration and fundamentally altering run-off friction coefficients and times of concentration.

The accommodation of high levels of urbanisation can only take place by alterating the physical landscape. Large-scale urbanisation of an area has the potential to threaten both the biodiversity and the ecosystem functioning of the affected areas through surface modification of the soils and landscaping, in combination with increased motor vehicle infrastructure (South Africa. Water Research Commission & Department of Water Affairs and Forestry, 2006). Robson, Spence & Beech (2005: 206) identify a clear link between an increasing coverage of impervious surface to a declining biological state of natural watercourses. Further impacts of urbanisation include (Stone, 2004: 102):

- Stream channel erosion;
- Diminished groundwater recharge;
- Impact on regional climate;
- High levels of run-off intensity, and
- Degradation of streams, rivers and lakes.

In light of the above impacts, hard engineered storm water conveyances are no longer viewed as a sustainable storm water management approach in isolation. The South African Water Research Commission & Department of Water Affairs and Forestry (2006) identified the de-canalisation and re-vegetation of water courses in a bid to rehabilitate natural stream courses as a strategic focus point in the operationalisation of the Integrated Water Resources Management (IWRM) strategy.

The issues of storm water management are by no means a locally isolated phenomenon. The EU's Pan-European initiative to develop an Adaptive Decision Support System (ADSS) for the integration of storm water source control into sustainable urban water management strategies under the 'Project Daywater' initiative, identified by Martin, Ruperd & Legret (2007: 339), serves as an example of the scale of storm water management challenges.

2.2.2 Pollution as an economic impact factor in urban storm water

In addition to the actual flow, volume, and morphological implications, the pollutant loading of a high-density urban environment has a profound impact. Goonetilleke, Thomas, Ginn & Gilbert (2005: 31) identified storm water as having a major influence on water quality as a result of being the primary transport mechanism for the introduction of chemical, biological and physical pollutants to receiving water bodies. Studies into the quality of storm water identify land use as the most significant consideration (Goonetilleke *et al.*, 2005: 40). High levels of toxicity have been specifically attributed to roadway run-off and studies in the San Francisco Bay area identified toxicity in over 90% of highway run-off samples (Kayhanian, Stransky, Bay, Lau & Stenstrom, 2008: 386).

The current CoJ storm water policy seeks only to regulate storm water discharge in terms of peak discharge rates from a development without quality intervention measures and no prescribed pollution limits or quantifiable storm water quality guidelines. The proposed CoJ CMP aims to address the problem of pollution in storm water by introducing chemical, bacteriological and thermal metrics for storm water discharges in future, in line with national legislation, but at present no further implementation details or guidelines exist. This inclusion of pollution control requirements has the potential to notably impact on the private property development sector and the supporting engineering community from a cost perspective.

2.3 Storm water legislation

In order to fully appreciate the potential economic impact of storm water management, the policy framework under which developers operate must be briefly considered. The subsequent overview of the salient points of international and local policies provides invaluable insight into the challenges impacting the accommodation of policy requirements in respect of storm water management inclusion and the potential for a negatively perceived economic impact.

2.3.1 Policy trends

International awareness and intervention in dealing with storm water-related issues can be found in a plethora of regulation aimed at controlling the complexities of urban storm water run-off. Canada, Scandinavia, the United States, New Zealand, the United Kingdom, Australia, Germany and France, among others, have adopted strategies and policies to address storm water issues. A point of commonality is the almost ubiquitous implementation of a financial charge, tax or rebate attributed directly to influencing storm water run-off. Further commonalities exist in the implementation of public education campaigns that form a part of the municipal communications programme. Table 1 provides a summary of selected EU member states storm water policy support mechanisms.

Table 1: Methods applied internationally for the promotion of storm water source control measures

	Pilot projects	*Regula-tory restric-tions*	*Dis-charge control*	*Dis-charge fees / penal-ties*	*Storm-water fees*	*Tax breaks / Fee reduc-tion*	*Public subsi-dies*	*Inform-ation cam-paigns*
Sweden	✓	✓	✓		✓	✓		✓
Denmark	✓	✓	✓		✓	✓		✓
The Netherlands	✓	✓	✓	✓	✓		✓	✓
Germany	✓	✓	✓	✓	✓	✓	✓	✓
England	✓	✓	✓	✓	✓	✓		✓
France	✓	✓	✓	✓			✓	✓

Source: Adapted from Chouli Aftias & Deutsch 2007: 66

A notable differentiating factor between current international and local storm water policies is the approach to water quality. Quality measures dictate acceptable pollution and contamination values for urban storm water. The inclusion of quality criteria has been associated with notable increases in the cost of storm water management and facilities construction. Scheuler (2000) attributed over a third of pond construction costs to the provision of quality control measures in research conducted in the United States.

2.3.2 South African storm water policy

The National Water Act (NWA) serves as a key component of water-related legislation and places an onus of responsibility for the management of water resources on the local authority. In addition, section 19(1) of this Act places an obligation on the landowner, or person in control of land on which pollution occurs, to take action in preventing such occurrence (South Africa, 1998a: 32). The *NWA* definition of pollution is broad, and in the context of urban storm water includes alteration to organic load, chemistry, sediment load, temperature, peak flow, total run-off and rate of change of flow. Post-development urban storm water run-off has the potential to affect every one of the abovementioned pollution characteristics if not adequately addressed. Further legislation in the form of *The National Environmental Management Act (NEMA)* places a responsibility on all persons, including the local authority, to minimise disturbance to the ecosystem and avoid pollution and degradation of the environment (South Africa, 1998b: 11). The regulatory backdrop provides a clear responsibility for the control of storm water, placing this responsibility in the hands of the local authority. This, in turn, forms the basis of the storm water attenuation regulations currently implemented, and those proposed in the CoJ CMP.

2.3.3 City of Johannesburg – Storm water management legislative framework

The Integrated Development Plan (IDP) for the Johannesburg Metropolitan Area clearly indicates that the importance of an effectively implemented storm water policy is desirable, while highlighting current deficiencies and direct reference to the inclusion of on-site storm water attenuation (City of Johannesburg, 2004). The *2007/2008 Spatial Development Framework (SDF)* identifies the need to address storm water issues due to the capacity of storm water infrastructure being exceeded (City of Johannesburg, 2007). The responsibility for the implementation and management of storm water control objectives lies with the Johannesburg Roads Agency (JRA) (Johannesburg Roads Agency [Pty] Ltd., 2004: 41).

Property developers are, in terms of JRA legislation, required to allocate land and infrastructure within new developments to limit the run-off peak discharge to a level equal to that of the undeveloped state of the property through the use of attenuation ponds and certain minimum requirements. The owner of the attenuation facility bears full responsibility for the design, construction and maintenance of the facility, in addition to a duty of care in respect of ensuring the continued functioning of the system, and an obligation to ensure that it does not create a hazard to municipal, or surrounding properties (Johannesburg Roads Agency [Pty] Ltd., 2005).

The proposed CoJ CMP aims to adopt a more stringent storm water management approach, more financially onerous than current legislation, placing additional responsibility on both the developer and local authority. The adherence to, and achievement of the proposed criteria will carry an additional cost in both time and monetary terms within the overall development process, as well as requiring the application of sufficient resources to ensure that policy objectives are met. Brown, Claytor, Debo, Haubner & Reese (2001) identified the establishment of programme goals, requirements, components, priorities, organisational structure, staffing and funding as fundamental pillars in support of successful storm water management systems.

2.4 The economic impact of storm water control

The direct financial impact of the allocation of land to storm water attenuation requirements is a reduction in the total amount of developable land available, resulting in the potential to increase the cost of the remaining units to compensate for lost sales potential. An alternative to the potential increased costs is an increase in the overall development density pursued in compensation as identified by the USEPA (1995: online).

Storm water has long exerted an economic influence on the development environment and is typified by questions asked by developers such as: "How small can I make this detention pond and still meet the stated design requirements?" (Reese, 2006: online). Such questions are indicative of the situation should clear guidelines not be upheld. The need for regulation is further supported by Walker, Weedon & Nicolson (2007), who identify that all developments are a matter of economics, thus invariably giving rise to the issue of minimum allowable standards.

International experience identifies the initial risk premium attached to the implementation of attenuation and associated Best Management Practices (BMP) as unknowns, and have been cited as a limiting factor in widespread BMP adoption. The resistance has also given rise to public questions regarding the community benefits and additional future costs associated with the proposed systems, in combination with the long-term efficacy of the systems (Eason, Dixon, Krausse, Vesely, Sharp & Kviberg, 2005). Research undertaken for the Valley Creek watershed in South Eastern Pennsylvania indicated that little benefit was achieved at a watershed level as a result of detention pond inclusion, and that under specific instances the inclusion of detention basins exacerbated overall watershed peak flow rates (Emerson, 2003).

The economic impact of attenuation inclusion has relevance, particularly for the private developer in strategic impact areas such as property value, construction costs, land opportunity cost, maintenance costs, altered risk and liability profile as well as the potential impact of delay on project costs.

2.5 Storm water attenuation impact on property values

International research commissioned by the USEPA established that 'wet' ponds may experience the same 'waterfront effect' that is attributed to lakes, streams and other natural water features. The research aimed to quantify the positive increase in property value for units in view of suitably designed storm water facilities, as well as to track the longevity of this premium. The findings indicated a 5% to 30% premium, averaging to an approximately 10% increase in property value. The lifespan of this premium was shown to exceed 20 years based on the available data (Schueler, 2000a: 302). It was also found that in areas of property over-supply, properties with a 'waterfront' effect sold more rapidly, thus improving developer market competitiveness and differentiation, while potentially improving project cash flows.

Further evidence in support of the positive impact of aesthetically optimised 'wet' areas is indicated by USEPA research indicating improved profitability and enhanced sales rates (USEPA, 1995: online). Residents of selected Ontario suburbs indicated that 17% of residents would be willing to pay a premium to live adjacent to a 'wet' attenuation pond while over 50% of those living next to 'wet' attenuation ponds believed it added value to their property (Schueler, 2000b: 453).

Klein (2003) considered the land value implications of attenuation facilities and observed that the 'dry' pond storm water approach had the opposite effect to that of well-designed 'wet' ponds. The negative impact attributed to the immediate vicinity of 'dry' pond attenuation facilities was found to be between 4% and 10% lower than comparable unaffected real estate.

Emmerling-Dinovo (1995) conducted research in Illinois with regard to the impact of storm water detention basins on residential locational decisions. A clear preference and value increase was attributable to the proximity to a 'wet' pond basin. The perceived value was present even though the 'wet' ponds were poorly landscaped. The inclusion of 'dry' ponds was identified as a negative impact on the value of surrounding properties by between 3% and 10%.

The general trend within the current body of research indicates that a 'wet' pond facility has a positive influence on the value of surrounding properties while 'dry' ponds are associated with a reduction in perceived property value and are considered less desirable in the urban landscape.

2.6 Storm water attenuation pond construction cost factors

The construction of private attenuation facilities is an additional cost element to each new project. The direct pond construction costs include design, approval, geotechnical investigation and professional fees, in addition to actual construction costs.

Detailed studies undertaken at Clemson University, South Carolina, considered the cost of designing, installing, and maintaining storm water pond systems in relation to the level of pollutant removal achieved. The study further incorporated real cost factors other than water quality and volume discharge. These costs were identified as engineering costs, construction costs and landscaping wages in addition to land value. The results identified specialist engineering skills as a high cost factor, and land value as a major influence in total pond cost (Sharma, 2005).

Schueler (2000) identified the construction of ponds as possibly the largest 'out-of-pocket' expense paid by developers in meeting storm water management obligations. The scale at which attenuation facilities were implemented was also shown to have a significant influence on the economic impact of pond construction costs. Smaller ponds serving individual developments of less than five acres (2.02 hectares) had costs per volume between five and ten times higher than large ponds indicating the high level of economic inefficiency of fragmented local pond structures in comparison to that of larger regional or multi-site pond implementations. Figure 4 indicates the relationship between cost and catchment areas as determinants in pond costing for both quality and quantity parameters, a high relevance parameter in light of the proposed CoJ CMP objectives to include water quality criteria as a component of the proposed storm water management system.

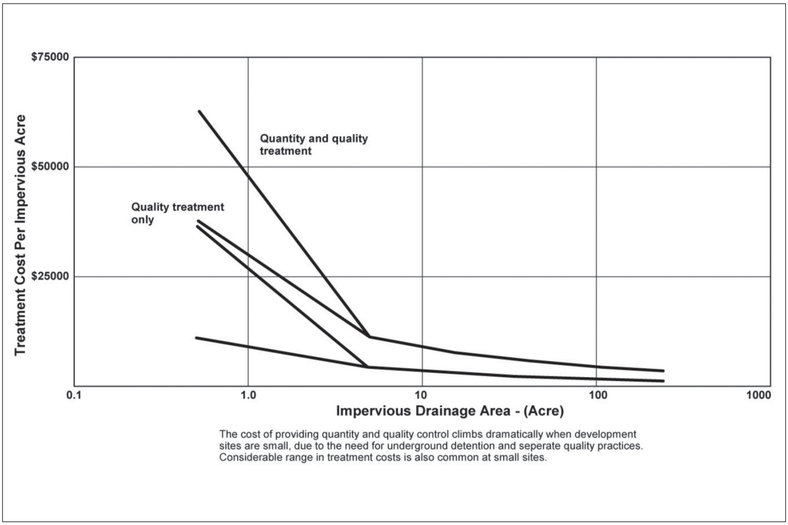

Figure 4: Generalised relationship between unit storm water management cost and site size.
Source: Adapted from Schueler 2000: 405

The current attenuation policy seeks to manage peak flows without consideration for water quality while the cost variance between constructing a quality influencing 'wet' pond versus that of a 'dry' extended pond structure was found to be marginal (Schueler, 2000). This finding is significant in light of the proposed implementation of quality criteria indicated in the CoJ CMP as a result of the far higher water quality control potential of 'wet' ponds as opposed to the currently preferred 'dry' pond approach. Research indicates that the inclusion of water quality criteria results in one-third of the total storm water construction costs being dedicated solely to quality management, the remainder being attributed to flood and hydraulic control (Schueler, 2000).

Based on the preceding international cost information it would appear that the introduction of storm water quality criteria for urban storm water management locally has the potential to pose a significant economic impact on private property developers.

2.7 Non-construction-related storm water attenuation pond cost factors

Wossink & Hunt (2003) identified the land opportunity cost of the loss of land resulting from the inclusion of storm water BMPs as the most important cost item, with an associated reduction in development profit and a frequent concern area for developer interests.

The current CoJ storm water policy does not allow for a reduction or reimbursement of costs for the construction or maintenance of the mandated private storm water structures or attenuation facilities. The Landcare Research Centre, in conjunction with the University of Auckland, presented an analysis of key economic factors influencing the uptake of storm water management practices. Research highlighted the question of how economically rational the development approach was for private property developers along with the equitable distribution of costs, and the long-term costs associated with the chosen systems (Eason *et al*., 2005). In a local context a lack of financial incentive appears to be a potential obstacle to the effective uptake and support of local storm water policy. The CoJ CMP draft policy has, in turn, made reference to providing possible credits against bulk contributions for storm water management programmes implemented (Brooker, 2006).

2.8 Storm water attenuation pond maintenance cost factors

Pond maintenance has a significant economic impact in the overall life cycle cost of the attenuation facility and is an area that is not specifically addressed by local legislation. In the current development environment there is no clearly defined maintenance requirement for pond facilities.

As the maintenance of an attenuation facility is paramount to the long-term successful functioning of the system in a manner that achieves the design objectives, the Ontario local government publication *Understanding Stormwater Management: An Introduction to stormwater management and planning* clearly states: "Lack of maintenance is one of the key reasons for poor system performance" (Ontario, 2003: 14). Thus the maintenance component of attenuation is one that results in lifetime costs associated with the benefits of the system. Maintenance considerations also play an important role in the design and specification of the system over and above the initial capital investment costs, as ponds often have a design lifespan in excess of 25 years. The Stormwater Manager's Resource Center places maintenance costs at between 3% and 5% of total pond construction cost per annum (Stormwater Manager's

Resource Center, n.d.: online). Maintenance activities include lawn mowing and landscape maintenance, removal of blockages and debris, clearing of litter, silt dredging and regular structural inspection (Wossink & Hunt, 2003). In the local development environment maintenance costs appear not to be considered; no definitive results or local data in this respect were encountered. The existing JRA Stormwater Attenuation Policy has no specific reference to a controlled or monitored maintenance requirement for new or existing attenuation facilities, thereby allowing the potential for the decreasing efficiency of installed facilities and a reduced utility return on the initial developer investment in meeting the prescribed standards.

Polta, Balogh & Craft-Reardon (2006: 62-69) investigated the contamination levels of pond silt and found contaminant concentrations that exceeded allowable levels, as well as linking the higher levels to increased roadway area within a watershed. The contaminated silt removed from affected ponds locally during maintenance may require specialised disposal in terms of *NEMA* and the *NWA*, incurring additional cost. Current regulations contain no specific guidance on contaminant target values or disposal guidelines for pond silt.

3. Research

3.1 Sample selection and data collection

The study examined a cross-sectional sample of affected developers using a structured, self-administered questionnaire. The sample stratum was based on achieving a diversified sample of the private property development arena by targeting small, medium and large developers within the defined geographic area of the CoJ. The focus sample included commercial, industrial and residential developments undertaken by private developers in the specified geographic area. Respondents were drawn randomly from a sample of companies listed with the South African Property Owners Association (SAPOA), as well as a randomly selected sample of organisations drawn from municipal and engineering consultancy sources, providing a final stratified sample group.

A response rate of 33% was achieved; twenty-one out of sixty-four questionnaires were returned. Responses were typically evaluated on a perceived level of impact based on a 5-point Likert scale.

4. Research findings

4.1 General storm water policy perceptions

Table 2 summarises the current views of private developers in respect of existing storm water policies.

Table 2: Developers' views of current storm water policies – general support levels

Parameter	Response (%)					
	Unsure	Disagree .... Agree				
		1	2	3	4	5
Consistent level of policy application	23 8	38 1	14 3	14 3	9 5	0 0
Positive environmental impact contribution	4 8	4 8	19 0	23 8	47 6	0 0
Policy adequacy for storm water control	19 0	4 8	9 5	33 3	28 6	4 8

Current policy implementations were viewed with a marked degree of scepticism regarding the perceived consistency of application, with 38.1% of the respondents indicating a value of 1. The implications of this view are the potential undermining of the policy and reinforcement of a negative view of storm water control and the potential to increase policy resistance levels while decreasing the overall impact of storm water management efforts.

47.6% of respondents tended to somewhat agree that the attenuation policy had a positive environmental impact, indicating a level of awareness of the intended benefits of the storm water management and attenuation policy under consideration. In addition, 33.3% of the developers perceived the attenuation policy to impact positively at a moderate level in terms of adequately addressing the issues of storm water control, while a further 28.6% indicated an above moderate level of agreement.

4.2 Levels of developer storm water-related policy knowledge

Storm water policy knowledge extents indicated below average to moderate levels, implying that significant scope remains for the improvement of policy dissemination by the CoJ, and assimilation within the development community. Respondents reporting knowledge levels above the median value may be in a better position to make informed policy decisions and develop a competitive advantage in the development arena. Results indicated that 52.4% of the respondents applied no effort in maintaining a current knowledge of storm water policy. In addition, results indicated that only 24% had ever received any storm water-related documentation from the CoJ. The results thus indicate a distinct lack of knowledge as a result of poor policy uptake and dissemination.

The low knowledge levels encountered are further supported by the high levels of reliance placed on external sources during the planning and feasibility stages. The levels of external reliance may be related to the lack of documentation available to developers prior to the appointment of a full professional team.

Table 3 shows that civil engineers were identified as the most important external consultants, with 86% of the respondents indicating a major significance, with a mean value of 4.76 (1 = least important, 5 = most important). Results indicated that the roles of the town planner and architect were potentially underestimated in respect of storm water accommodation during the initial spatial and aesthetic planning phases with mean contributory significance values of only 1.90 and 2.55, respectively.

Table 3: Rating of perceived importance of external consultants with respect to storm water attenuation

Parameter	*Response (%)*					
	Unsure	*Least important .... Most important*				
		1	*2*	*3*	*4*	*5*
Town planner	0 0	57 1	19 0	9 5	4 8	9 5
Architect	4 8	42 9	4 8	19 0	9 5	19 0
Civil engineer	0 0	0 0	4 8	0 0	9 5	85 7
Environmental consultant	4 8	19 0	9 5	19 0	14 3	33 3
Land surveyor	9 5	47 6	14 3	19 0	4 8	4 8

The research also considered which channels of communication were most likely to be effective in reaching the private property development community in mitigating the perceived economic impact through effective communication. The results are as follows (most likely to least likely): summarised guideline booklet, dedicated website, storm water policy manual, dissemination through SAPOA, and public presentation.

4.3 The impact of storm water attenuation costs on development feasibility

The impact of attenuation inclusion was perceived to be of major significance by 38.1% of the developers in respect of increased densities as compensation for lost utility while a further 19% indicated an above-average impact.

In response to research on the direct impact of attenuation inclusion on project feasibility, the results indicated that, in terms of overall feasibility, the majority of developers reported a moderate impact with a mean score of 2.60 (1=minor impact, 5=major impact), indicating a below-average impact. Selling prices of affected units were found to be only moderately affected, with a mean value 2.44 (1=minor impact, 5=major impact). The resultant low impact may be sensitive to the number of units contained in a development but development profitability was deemed to be only moderately impacted. The results indicate that the inclusion cost of an attenuation pond, when distributed over the total development, does not pose an overly adverse impact on project feasibility or property value.

The level of support for less land-intensive attenuation measures because of land lost to attenuation was fairly high as a mean value of 4.40 was recorded (1=low, 5=high)

4.4 The impact of storm water attenuation inclusion on property values

The research also evaluated the perceived economic impact of attenuation policy requirements *vis-à-vis* the effect on property prices in the immediate vicinity of pond facilities. Respondents indicated a moderate value impact with a mean of 2.83, indicating general developer awareness, but indicating that the influence of proximity is not considered to be a significant impact. Results specific to 'wet' and 'dry' pond types indicated that 'dry' ponds were considered to have a moderately negative impact on property value while 'wet' ponds exhibited an above-average negative impact. The results contrast with those previously identified by Klein (2003), Schueler (2000a: 302) and the USEPA (1995: online). Negative reactions to the 'wet' pond may be attributed to the visual impact of a permanent water pool and the associated issues of safety, aesthetics and pollution, as identified by Apostolaki & Jefferies (2005). Table 4 represents the results.

Table 4: The developer-perceived level of negative impact of attenuation pond proximity and type on property value

Parameter	Response (%)						Mean
	Unsure	Low..High					
		1	2	3	4	5	
Immediate proximity to attenuation pond	14.3	19.0	4.8	38.1	19.0	4.8	2.83
Proximity to 'dry'-type pond	9.5	14.3	9.5	38.1	14.3	14.3	3.05
Proximity to 'wet'-type pond	14.3	4.8	14.3	19.0	38.1	9.5	3.39

4.5 The perceived impact of storm water attenuation inclusion on maintenance costs and project delays

The inclusion of attenuation ponds in new developments was perceived to have a minor negative impact in terms of both the immediate and long-term maintenance costs for affected developments, with 38% of the developers citing maintenance considerations as being of minor importance during feasibility and design activities. Limited maintenance impact may be attributed to the short-term nature of developer involvement over the lifecycle of the development. Thirty-eight percent of the developers indicated that long-term maintenance costs had a potential negative financial impact on affected development management bodies. At present no effective regulatory mechanism exists to monitor attenuation facility maintenance and the negligible consequences for neglect support the perception of marginal economic impact for developers.

Low levels of developer knowledge currently exist in respect of maintenance requirements with 19% of the developers having no knowledge of maintenance and 47.6% falling at a below-average knowledge level. The current knowledge levels have the potential to impact negatively on development economics, as well as long term sustainability.

Attenuation pond inclusion was strongly perceived by developers to increase the number of delays in both plan approval and completion approval. The economic impact of delays was attributed to higher holding costs, delayed transfer and the concomitant cash flow implications. The issuance of clearance certificates is closely tied to development finances and elicited above average response levels as indicated in Table 5.

Table 5: The perceived impact of approval and clearance delays directly attributed to stormwater attenuation inclusion

Parameter	*Response (%)*						*Mean*
	Unsure	*Minor*.. *Major*					
		1	*2*	*3*	*4*	*5*	
Approval delays	4.8	4.8	14.3	23.8	23.8	28.6	3.60
Final clearance	4.8	4.8	14.3	19.0	28.6	28.6	3.65

A response to the specific implementation of a greater level of stormwater control as proposed in the draft CoJ CMP resulted in 42.9% of the developers indicating an above-average level of opposition to the proposed measures, with the mean value of 3.68 highlighting the development community sensitivity towards a perceived negative impact on the development process through additional resources for compliance and an increased potential for delay.

4.6 Storm water attenuation pond inclusion impact on project risk

The mandatory inclusion of attenuation facilities provides an additional level of responsibility for developers and their subsequent successors in title. Apostolaki & Jefferies (2005) identified safety risk concerns as a high priority in community surveys conducted in the United Kingdom. Local developers indicated an above-average level of additional risk as a result of pond inclusion, with particular regard to the safety measures and potential for liability and associated claims. A risk response was evaluated relative to the criteria below, with mean results indicating a consistently low to below-average risk impact response (1=Low, 5=High risk):

Table 6 indicates that the mean rating for all the perceived risks are below average (3.0), indicating that the developers perceive a below-average level of concern from a risk perspective. Risks associated with 'maintenance-related pond failure' are ranked highest while 'catastrophic pond collapse' is ranked last.

Table 6: Risk factors attributable to storm water attenuation pond inclusion

Risk factor	*Response (%)*						*Mean*	*Ranking*
	Unsure	*Low...High*						
		1	*2*	*3*	*4*	*5*		
Maintenance-related pond failure	0.0	23.8	28.6	19.0	28 6	0.0	2.52	1
Adequacy of design	0.0	28.6	38.1	14.3	14 3	4.8	2.29	2=
Danger to residents	0.0	38.1	23.8	14.3	19 0	4.8	2.29	2=
Pond-related litigation	9.5	33.3	28.6	14.3	14 3	0.0	2.11	3
Design-related failure	0.0	38.1	33.3	9.5	19 0	0.0	2.10	4
Flood risk to neighbours	4.8	33.3	33.3	19.0	9.5	0.0	2.05	5
Catastrophic pond collapse	4.8	33.3	47.6	4.8	9.5	0.0	1.90	6

The low risk perception appears to be supported by a level of confidence in storm water attenuation pond design, low levels of liability litigation encountered in South Africa and low levels of safety awareness. Current local legislation does not directly address the risks of attenuation pond inclusion on the safety of residents. In addition, attenuation regulations have only been in effect for a relatively short period and have not been tested by exceptional hydrological events.

5. Summary and conclusions

Developers exhibited moderate knowledge levels of the current CoJ storm water attenuation policy as implemented by the JRA coupled with poor levels of knowledge of the proposed CoJ Catchment Management Plan, CoJ development documentation and national legislation, while noting the lack of CoJ storm water policy documentation and guidelines as a constraining factor.

Overall project feasibility was not perceived to be highly influenced by the storm water attenuation policy but did indicate a high level of support regarding a perceived increased development density as compensation for the inclusion of storm water attenuation ponds as a means to accommodate the lost opportunity cost of pond inclusion. The feasibility, profitability and impact on per unit selling prices were found to be of a below-average level of concern for developers indicating that pond inclusion was not ultimately viewed as a significant hindrance to projects in financial terms.

The perceived impact of the proximity of properties to storm water attenuation ponds was deemed to be negative for both 'dry' and 'wet' ponds. However, 'dry' ponds posed a lower impact while 'wet' ponds did not exhibit the positive 'pond premium' identified in US research. Developers further indicated a below-average level of effort expended in incorporating attenuation through landscaping and aesthetic enhancement.

Maintenance considerations during feasibility analysis and pond design stages received little consideration; indications were that maintenance costs for storm water facilities were not deemed a significant burden to the managing bodies of new developments. In addition, the current level of maintenance knowledge within the development community indicated below-average levels, potentially resulting in limited maintenance to many new facilities.

The impact of attenuation inclusion on project delays indicated that an above-average to major level of delay was associated with the approval and final completion processes in place. The results showed that attenuation inclusion played a prominent role as a potential project delay in the private development environment. In addition, the research results indicated that developers were opposed to the introduction of more stringent storm water controls as proposed by the CoJ.

The inclusion of storm water attenuation ponds was perceived to pose an above-average level of risk in terms of liability for the associated safety risks but was not otherwise considered to markedly impact a typical project risk profile and therefore presented limited economic impact.

6. Recommendations

6.1 General

The current storm water landscape policy holds a great deal of uncertainty for the private property developer as an integral part of the urban project delivery system, ultimately contributing to the economic growth of the CoJ. Developers require a clearly defined and efficient policy that encompasses the objectives of sustainable and environmentally conscious urban storm water management within attainable economic boundaries.

General recommendations include educational programmes focused on developers and community residents, demystifying pond-related issues, and mitigating negative impressions while creating credibility in the eyes of both the public and the developer.

Ongoing storm water research is recommended in order to provide quantifiable evidence as to the effectiveness of the storm water policy measures and economic benefits. The CoJ is home to a number of well-respected educational institutions with established research programmes that may be leveraged to benefit their immediate environment in respect of local storm water management studies. Research should also be conducted in other South African cities to analyse whether results are similar.

6.2 Policy knowledge levels

The poor level of storm water management policy knowledge identified requires extensive action on the part of the local authority. It is recommended that, in addition to the fundamental recommendations contained in the CoJ's CMP, the CoJ should develop a comprehensive technical guideline document outlining the acceptable technical parameters, design requirements and performance metrics required, suitable for use by professional engineers, with a condensed version applicable to developers and other relevant professionals.

This is supported by Botha (2005) who identified the lack of a storm water design manual and integrated storm water planning as major constraints in the successful implementation of storm water management for the CoJ area.

Developers identified the three preferred means of communication of storm water policy information as being a summarised guideline booklet, a dedicated website and a storm water policy manual. This can readily be accommodated within the well-developed and expanding e-services infrastructure of the CoJ.

6.3 Project feasibility and property value

The CoJ should consider a broader range of BMPs that can be applied such as subterranean facilities or alternatives such as permeable paving that limit the impact of lost surface area in combination with the development of an incentive/rebate scheme to offset the impact of increasing storm water management requirements.

6.4 Property value impact

A long-term education and promotion effort should be maintained in support of developing a positive relationship between attenuation facilities and property values, by leveraging the proposed CoJ CMP water quality requirements and the positive impacts of 'wet' ponds, thereby unlocking value through landscaping and aesthetically sensitive design. Greater integration of the CoJ open space and green areas management may further support increased values and provide suitable areas for storm water management on public land, including the use of regional attenuation structures.

6.5 Project delay

The recommendations in response to alleviating the impact of the perceived delays attributed to storm water attenuation policy relate to increasing the CoJ and JRA capacity, ensuring consistency of standards, standardised technical parameters, and improved communication structures. Delays in the issuance of clearance certificates and approvals may be further reduced through an increased level of knowledge and awareness in the development community, engineering field, and associated professions, in tandem with clear technical documentation and supporting guidelines.

6.6 Maintenance

Detailed design documentation should include typical maintenance costing to enable developers and designers to quantify typical costs for various attenuation options while the development of an attenuation pond manual issued to all management bodies of pond affected developments is recommended. The details should include guidelines on the intent, functioning, and maintenance responsibilities required with regard to attenuation ponds. Examples of such guides include the publication *Maintaining your BMP – A Guidebook for Private Owners and Operators in Northern Virginia* (Northern Virginia Planning District Commission, 2000). Long-term maintenance incurred by an affected development body may be suitable for a rebate system quantified in relation to minimum maintenance requirements.

6.7 Project risk

Although the majority of attenuation facilities are privately owned, it is recommended that the CoJ provide safety guidelines as part of the proposed technical manual and developers' guide, encompassing safety, functional aesthetics, physical risks and health risks. The safety of dams, addressed by Brooker (2006) in the CMP, should include a pond inventory, inspection schedule and GIS integration as part of an ongoing long-term monitoring programme to provide supporting data aimed at refining attenuation requirements based on historical performance.

7. Conclusion

Climate change with resultant intense storms, together with less vegetation (forests and tall grass veld) as a result of urbanisation, has lead to increased emphasis on finding ways to control storm water. Where there are rivers in the area, efforts could also be made to channel the water into these rivers. An urban river can be an asset to residents of the area; it should be a place where they can relax, with relatively good quality, controlled stream flow, lush vegetation where birdwatching, and even fishing should be possible (De Villiers, 2004: 108).

The long-term economic sustainability of storm water management is dependent on a supportive policy environment as storm water will continue to remain a challenge in the face of urbanisation and accelerated densification.

References

Aldous, M. 2007. Picture of typical open-air storm water attenuation pond in the Johannesburg area. Authors' own collection.

Apostolaki, S. & Jefferies, C. 2005. *Social impacts of stormwater management techniques including river management and suds*. Edinburgh. Scotland and Northern Ireland Forum for Environmental Research.

Botha, N. 2005. Stormwater management and related urban environmental issues along the Fourways Spruit. Unpublished MA thesis, University of Johannesburg, Johannesburg.

Brooker, C.J. 2006. Draft Catchment Management Policy – February 2006. Johannesburg: City of Johannesburg Environmental Management Department.

Brown, T., Claytor, R., Debo, T., Haubner, S. & Reese, A. 2001. *Georgia Stormwater Management Manual*. Volume 1: Stormwater Policy Guidebook. Georgia Department of Natural Resources - Environmental Protection Division.

Chouli, E., Aftias, E. & Deutsch, J. 2007. Applying storm water management in Greek cities: Learning from the European experience. *Desalination,* 210(1-3), pp. 61-68.

City of Johannesburg (CoJ). 2004. *Integrated Development Plan 2004/2005*. Johannesburg, City of Johannesburg.

City of Johannesburg (CoJ). 2007. *Spatial Development Framework – 2007/2008*. Johannesburg, City of Johannesburg.

De Villiers, G. du T. 2004. The management of urban rivers. *Acta Academia,* 36(3), pp. 98-110.

Eason, C., Dixon, J., Krause, M., Vesely, E., Sharp, B. & Kviberg, K. 2005. *Low impact urban design and development: Making it mainstream*. Auckland. Landcare Research and the University of Auckland.

Emerson, C.H. 2003. Evaluation of the additive effects of stormwater detention basins at the Watershed Scale. Unpublished MSc thesis, Drexel University, Pennsylvania.

Emmerling-Dinovo, C. 1995. Stormwater detention basins and residential locational decisions. *Water Resources Bulletin*, 31(3), pp. 515-521.

Goonetilleke, A., Thomas, E., Ginn, S. & Gilbert, D. 2005. Understanding the role of land use in urban stormwater quality management. *Journal of Environmental Management*, 74(1), pp. 31-42.

Johannesburg Roads Agency (Pty) Ltd. 2005. Faxed memo to consultants, Stormwater Management - JRA Policy Statement. 30 November 2005.

Johannesburg Roads Agency (Pty) Ltd. 2004. The vehicle that makes the city work. *Journal of the Institute of Municipal Engineers of South Africa (IMIESA)*, 29(2), pp. 41.

Kayhanian, M., Stransky, C., Bay, S., Lau, S.L. & Stenstrom, M.K. 2008. Toxicity of urban highway run-off with respect to storm duration. *Science of the Total Environment*, 389(2-3), pp. 386-406.

Klein, R.D. 2003. *Development issues: A citizen's guide to preserving and enhancing quality of life in developing areas*. Maryland: Community and Environmental Defense Services.

Martin, C., Ruperd, Y. & Legret, M. 2007. Urban storm water drainage management: The development of a multicriteria decision aid approach for best management practices. *European Journal of Operational Research*, 181(1), pp. 338-349.

Northern Virginia Planning District Commission. 2000. *Maintaining your BMP: A guidebook for private owners and operators*. Northern Virginia Planning District Commission, Division of Environmental Services.

Ontario, 2003. *Understanding storm water management: An introduction to storm water management planning and design*. Ontario: Queen's Printer for Ontario.

Polta, R., Balogh, S. & Craft-Reardon, A. 2006. Characterization of storm water pond sediments Final Project Report - EQA Report 06-572. St. Paul, MN. Metropolitan Council Environmental Services, Environmental Quality Assurance Department, Research & Development Section.

Reese, A.J. 2006. Voodoo Hydrology. *Stormwater*, [online], 7(5), July / August. Available from: <http://www.stormh2o.com/july-august-2006/urban-hydrology-methods.aspx> [Accessed: 31 August 2007].

Robson, M., Spence, K. & Beech, L. 2005. Stream quality in a small urbanised catchment. *Science of the Total Environment*, 357(1-3), pp. 194-207.

Schueler, T.R. 2000. The economics of storm water treatment: An update, Article 68. In: Schueler, T.R. & Holland, H.K. (eds.). *The practice of watershed protection*. Ellicott City, MD: Center for Watershed Protection, pp. 401-405.

Schueler, T.R. 2000a. The pond premium, Article 81. In: Schueler, T. R. & Holland, H. K. (eds.). *The practice of watershed protection*. Ellicott City, MD: Center for Watershed Protection, pp. 302-303.

Schueler, T.R. 2000b. Human and amphibian preferences for dry and wet storm water pond habitat, Article 84. In: Schueler, T.R. & Holland, H.K. (eds.). *The practice of watershed protection*. Ellicott City, MD: Center for Watershed Protection, pp. 453-454.

Sharma, R. 2005. An economic analysis of costs of bioretention cells and stormwater ponds. A paper presented at the South-Western Economics Association Annual Meeting, New Orleans, Louisiana, 24-26 March.

South Africa. 1998a. *National Water Act No. 36 of 1998. Pretoria*: Government Printer.

South Africa. 1998b. *National Environmental Management Act No. 107 of 1998*. Pretoria: Government Printer.

South Africa. Water Research Commission and Department of Water Affairs and Forestry. 2006. Proposed Integrated Water Resource Management Plan Guidelines for Local Authorities - Discussion Document, Project No. K8/116.

Stone, B. 2004. Paving over paradise: How land use regulations promote residential imperviousness. *Landscape and Urban Planning*, 69(1), pp. 101-113.

Stormwater Manager's Resource Center. n.d. Stormwater Management Fact Sheet: Dry Extended Detention Pond. Available from: <http://www.stormwatercenter.net/> [Accessed: 11 July 2007]

USEPA. (United States. Environmental Protection Agency). Office of Wetlands, Oceans and Watersheds (4503F). 1995. Economic Benefits Of Run-off Controls. EPA 841-S-95-002. [online]. Washington, DC. Available from: <http://www.epa.gov/nps/runoff.html> [Accessed 11 July 2007].

Walker, D., Weedon, M. & Nicolson, G. 2007. Environmentally responsible development: Case study of a residential development within the eThekwini Municipality. Paper presented at the Annual IMESA Conference, International Convention Centre, Durban, 23-26 October 2007.

Wossink, A. & Hunt, B. 2003. The economics of structural stormwater BMPs in North Carolina, Publication 344, Raleigh, NC. Water Resources Research Institute of the University of North Carolina.