Water use in urban schools in Gauteng North, South Africa

by

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Submitted in fulfillment of a part of the requirements for the degree

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DECLARATION

I declare that this research is my own unaided work, except where otherwise stated.
This dissertation is being submitted in partial fulfilment of the requirements for the degree MSc (Quantity Surveying) at the University of Pretoria. It has not been submitted before for any degree or examination at any other university.

…………………………
N. N. Oliver
September 2005

SYNOPSIS

WATER USE IN URBAN SCHOOLS IN GAUTENG NORTH, SOUTH AFRICA

by

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DEPARTMENT: **Construction Economics**
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Water is undoubtedly one of South Africa's most valuable resources. Without significant improvement in the efficiency of use of this resource, we may experience wide-ranging shortages throughout the country within the not too distant future.

The educational sector in South Africa could play a pivotal role in the education of learners and their communities, relating to the responsible use of water. This education, however, requires a parallel demonstration of these values within the boundaries of the school yard in order to maintain credibility amongst those being taught, and to enjoy the financial and environmental benefits of water saving initiatives.

Primary and Secondary Schools in South Africa currently accommodate approximately 11,6 million learners and 360,000 educators. These learners and educators are accommodated in 27,200 schools, of which approximately 19,600 urban schools are supplied with water on site. Included in these schools are approximately 75,000 hostel beds, with supporting infrastructure such as canteens and laundry facilities. Other water uses within these schools include 63,700 sports facilities for various sports codes such as swimming, rugby, soccer, hockey, athletics, cricket and volleyball. Specialist laboratories, home economics and science centres total approximately 3,400. (National Department of Education, 2001, Schools Register of Needs).

This portfolio of facilities represents a major water use within South Africa, costing schools and the Department of Education, approximately R216m per annum, plus estimated losses, due to leakage and wastage of approximately R74m per annum. This study has also shown that billing under-recovery to local supply authorities, providing water to schools, amounts to approximately R90m per annum.

Based on cursory audits of 64 schools in Gauteng North, as well as their utility service provider accounts, this project sets about defining key performance indicators for use by schools to assist with the management of their water resource use. A simplified, paper-based water use simulation tool is developed for use by schools nationally, in establishing an ethic of measuring and monitoring within their institutions.

School water use is fragmented, at facility level, into various major uses, including ablution consumption, irrigation of sports fields and landscaping, other ancillary uses and water losses, due to leakage and wastage. This project outlines the impacts, financial and environmental, of school water efficiency initiatives, illustrating technology options using life-cycle costing studies, and desktop simulations.

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CHAPTER 1: THE PROBLEM AND ITS SETTING

1.1 Sustainable development

In the wake of the recent World Summit on Sustainable Development, held in Johannesburg during September 2002, the world is turning its attention to the equitable distribution and responsible use of resources, such as water, to ever increasing numbers of the earth's inhabitants. The increased demand on these resources may result in wide ranging shortages, if a responsible attitude is not adopted in their management and use. Attitude, however, requires ensuing actions in order to be effective.

The International Council for Research and Innovation in Building and Construction (CIB) and the United Nations Environment Programme - International Environment Technology Centre (UNEP-IETC), recently commissioned the compilation of a discussion document entitled "Agenda 21 for Sustainable Construction in Developing Countries". This document defines "sustainable construction", as not only the procurement and assembly of bricks, mortar, concrete and steel, but extends the envelope backwards to project inception, and forwards, through operation and maintenance, to the final demise, or deconstruction and disposal of the built facility. The following excerpts summarise this view:

"It should be recognised that mankind is locked into a highly dynamic relationship with the natural world, and that the two are acutely interdependent. In addressing the complex problem of construction and the environment, efforts towards sustainable construction are fundamentally an attempt to put in place properties that restore the balance between the natural and built environments. It is a search for an ecological model that views both realms as fundamentally interconnected.

Sustainable construction is seen to imply holistic thinking as regards construction and management of the built environment, taking a lifecycle perspective. It implies not only new environmentally orientated construction designs, but also new environmentally friendly operation and maintenance procedures" (CIB / UNEP-IETC. 2002. pp. 8-9)

1.2 Water in South Africa

"Water is life. In South Africa it is a crucial element in the battle against poverty, the cornerstone of prosperity and a limiting factor to growth. As a fundamental and indispensable natural resource, no regional or national development plan can take shape without giving primary consideration to water.

We cannot afford the luxury of continuing to use water without considering its most beneficial use, or be sidetracked by taking short-term measures while a real crisis develops around us. Our water should be applied to best advantage to achieve the greatest overall benefit for the country in an environmentally sustainable manner." (Department of Water Affairs and Forestry. 2002)

Water is undoubtedly one of South Africa's most valuable resources. Without significant improvement in the efficiency of use of this resource, we may experience wide-ranging shortages throughout the country within the not too distant future. The Department of Water Affairs and Forestry are currently striving to raise national awareness levels, amongst all groups of water users, from heavy industry to residential.

Vickers (2001) maintains that conservation programmes that rely on incentive-only approaches (public education campaigns, rate strategies and policies and regulations) may send a conservation message. It fails, however, to accomplish the next step, which is getting people to do something practical that saves water.

In the commercial and residential sectors many measures are upheld, in literature and case studies, as cost-effective in implementing water conservation. Measures, such as improved maintenance of water devices, replacement of faulty tap washers, adjustment of flush valve timings, complete replacement of continuous automatic flushing devices, rainwater harvesting and gray-water recycling, are available to property and facility managers, resulting in immediate and significant reductions in water consumption. Flow controllers in taps, reduced flow shower heads and careful planning of water reticulation, particularly hot water reticulation, are low cost measures yielding reasonable pay-back periods on capital investment for the property owner and tenant.

1.3 The primary and secondary education sector in South Africa

Primary and Secondary Schools in South Africa currently accommodate approximately 11,6 million learners and 360,000 educators. These learners and educators are accommodated in 27,200 schools, of which approximately 19,600 urban schools are supplied with water on site. Included in these schools are approximately 75,000 hostel beds, with supporting infrastructure such as canteens and laundry facilities. Other water uses within these schools include 63,700 sports facilities of various types incorporating swimming pools, rugby, soccer, hockey, athletics, cricket and volleyball fields. Specialist laboratories, home economics and science centres total approximately 3,400. (National Department of Education, 2001, Schools Register of Needs)

A preliminary desk top analysis, by CSIR: Green Buildings for Africa, estimates the total water use by learners and staff, in urban schools, to be approximately 43 Mega litres per annum (R170m per annum), with an additional 32 Mega litres estimated to be used annually in the irrigation of sports fields. A further 10 Mega litres per annum may be lost due to poor maintenance and management, with a great number of opportunities for water conservation in reducing water costs and increasing the variety of measures employed to curb wastage. Water conservation is already being integrated into the teaching curriculum, and further publicised and implemented within surrounding communities. Professor Asmal (South Africa 1999) advises that the role of the school facility within communities in South Africa is rapidly changing to become a catalyst for continuous learning and to serve local communities in the provision of community meeting, training and sports facilities. With this extended use of existing and new schools, the opportunities for demonstrating effective conservation and for education in water conservation, management and use are equally extended.

The Department of Water Affairs: Directorate Water Conservation's "2020 Vision for Water Programme" has succeeded in exposing the Department of Education's schools curriculum development to the need for water conservation in South Africa, and has established a solid network relationship between the two departments at National, Regional and District levels. Based on informal observation, it seems that aside from curriculum injection into the OBE teaching system, little fruit is currently evidenced in the management and maintenance practices within schools themselves, with little or no national data available for the comparative assessment of schools' performance. The result: Learners and their affected communities seem to be learning the virtues of water conservation *in theory*, and are not seeing a practical outworking of these concepts within the boundaries of their school facilities.

1.4 The cost of schooling in South Africa

The South African Schools Act of 1996 requires that the management of all schools throughout South Africa is devolved to School Governing Bodies. This management responsibility includes not only the day-to-day administration of learners, teaching and curriculum, but extending into the domain of property management, maintenance and the generation of additional funding. Many schools are required to cover the costs of utility accounts (water, energy and waste removal) from income generated from learners' school fees. In addition to monthly utility bills, additional staffing, purchases of equipment and educational programmes are funded from the same shrinking funding source. A reduction in utility use, through concerted water and energy efficiency interventions, would release funding to alternate, more valuable areas of application.

The National Department of Education (2003) identifies the following elements of costs for attention by the Department over the next few years:

- Budgetary practice linked to school-level resourcing;
- Teacher utilisation (incorporating timetabling, technology in the classroom and admin support);
- Strengthening teacher capacity;
- Organisational and procurement improvement (incorporating procurement, monitoring and management of non-personnel resources, electricity, water, etc.);
- Prices of services and goods procured;
- Cost of textbooks;
- Cost of uniforms;
- Improved asset management systems in schools (FM and asset registers);
- Textbook retrieval systems;
- Respecting basic human rights;
- Nutrition;
- Funding norms and standards;
- Learner transport;
- Infrastructure development;
- Performance monitoring systems.

1.5 The main research task

This study proposes to assist in creating an enabling environment, within the South African educational sector, for the identification and implementation of cost-effective measures, within the water installations of new and existing urban school facilities. Desktop simulations using data samples collected from schools in the field, water installation technologies currently available in South Africa, and management and maintenance practices observed within the sampled schools will form the basis of these studies.

The principal problem may be formulated as follows:
Can a model be developed for baseline calculations of water consumption in South African schools?
In order to meaningfully approach this investigation, the study is divided into three separate sub-problems, as follows:

1.5.1 Sub-problem 1

As with many facilities, water use is measured at the incoming service provider's meter, with no further measuring or monitoring of water use by specific processes occurring within the facility. These processes may be broadly categorised into core processes, and supportive processes. Core processes within the school would include those supporting educational activities within the facility, cleaning, ablutions, hostel accommodation, etc. Supportive processes would include landscaping, gardens and sports fields, not directly affecting the educational core processes of the school.

There is a need to determine the water consuming processes, occurring within the educational facility, the magnitude of consumption, and a measure of the efficiency of this water use. Comparative assessment of water consumption, in various types of schools, requires the development of appropriate normalised performance indicators.

How much water is consumed by the core education-related processes occurring in schools?

1.5.2 Sub-problem 2

The extent of grounds and landscaped gardens incorporated into school grounds may affect the total consumption of water by the school. Irrigation protocols and methodologies may also significantly affect the patterns and volumes of water consumed.

How much water is consumed in the irrigation of landscaped gardens and sports fields?

1.5.3 Sub-problem 3

Water installation components installed at schools may have been selected by architects, specifiers, or maintenance personnel, based on criteria such as price, availability, familiarity, and so on. Some indication of the performance, in the line of duty, of these components would provide useful information to these specifiers and maintenance personnel for future consideration. Capital investment requirements, immediate savings yielded and projected life cycle benefits may be illustrated to promote, or detract from decision-making related to water saving interventions within the school, such as technology changes, facility management and maintenance protocols.

How does the installed technology influence water use in schools?

1.6 The hypotheses

Water consumption in schools should be separated into major process groups:
Water consumed in ablutions, facility cleaning and teaching activities. Consumption by automatic flushing urinals, WC's and washbasins should be estimated. Water consumed in hostels, including laundries and kitchens. Consumption in ablutions / cleaning, kitchens and laundries should be separated;
Water consumed in the maintenance of landscaping and sports facilities;
Water lost to leakage, vandalism and installation component failure.

With appropriate data analysis and interpretation, an effective model may be constructed to determine baseline water consumption in schools.

The following hypotheses regarding the above sub-problems have been set:

1.6.1 Hypothesis 1

No detailed information was discovered during the literature survey to provide anticipated proportions of water consumption in schools.
Based on the findings of Robson (1966), the daily water consumption per learner Full-Time Equivalent (FTE), resulting from learning and ablution processes, will account for 21 litres per FTE per annum.

1.6.2 Hypothesis 2

Schools with limited or no sports facilities and gardens will indicate lower consumption. Where irrigation is carried out, those schools with strict irrigation control procedures or equipment will indicate lower water use.

Therefore, from information gathered during the literature survey:
Based on the findings of Tondut (1976), the daily water consumption per FTE, resulting from irrigation of external areas, including sports grounds, will account for 63 litres per FTE per annum.
Metering and timing of irrigation systems will reduce irrigation use by 20%.

1.6.3 Hypothesis 3

Based on evidence gathered during the literature survey:

- Low water demand technologies fitted in school ablutions will reduce ablution water use by 15%.
- Water losses, due to faulty installations and leakages, will account for an average of 30% of total water consumption.
- Secondary schools will consume more water per FTE than Primary Schools, due to higher incidence of vandalism and larger sports facilities.

Hypotheses to the stated research problem and sub-problems were constructed in this section.
Given the large and distributed nature of schools throughout South Africa, and the complexity of gathering useful data for the purposes of this task, the following section lists the limitations placed on the study.

1.7 Project limitations

1.7.1 Project delimitation

This study has been limited to water conservation measures and opportunities within urban schools. This allows the researcher access to utility supply accounts from local supply authorities, in order to determine water consumption and costs. Rural schools would, if supplied with water, be supplied from farm supplies, streams, springs or tanker deliveries, with little or no metering or record of usage.

Due to the costs incurred in physical site visits and inspections, the sample will be limited to those urban schools situated within Gauteng North, which is an area within easy motor access from the researcher's base. A systematic sample of schools will be used for the purposes of the study.

1.7.2 Cause and effect

The water use cycle is a complex system within which water is harvested for use from primary groundwater sources, dams and rivers and secondary rainwater storage and wastewater recycling storage.

Water storage, transport, pumping, treatment (in many parts), distribution to and application at point of use, are all elements of this complex process. Harvesting of wastewater and rainwater may inject useable water back into the cycle at various points.

Major considerations within the water use cycle would include security of supply, storage, handling and transport capacities and costs, environmental impacts of these facilities, energy consumption, chemical consumption, job creation, "unaccounted for water" within the supply chain and installed technological efficiencies.

Water conservation measures, at any point in this water use cycle, would directly impact on the cost of water to the consumer. Indirectly, impacts would include reductions in wastewater generation and loading at the treatment plant, cost of transport and treatment. Other indirect impacts would include reduction in demand, pumping and storage costs, treatment costs and purification works loading, demand on the primary water sources.

For the purposes of this study, the direct benefit to the consumer only has been considered. That is, then volume of water consumed and the cost of that water to the school. This cost would be carried by the school, in the case of Section 21 schools, and by the Department of Education, in the case non-Section 21 schools.

1.7.3 Water consumption data

Various methods are recognised for the measurement of water consumption by a consumer. These methods include municipal supply authority water meter readings, or alternatively, the installation within the consumer's property of a suitable water meter, from which consumption readings may be taken. This is a costly exercise, and requires cognisance to be taken of a number of important factors; should the incoming water main also supply the internal fire services within the facility, the water meter should be adequately sized to avoid water starvation at fire appliances, should an emergency arise. Since vandalism is prevalent within most school facilities, the new meter would also require to be housed in some vandal proof enclosure, or meter box. Measurement of water consumption from installed metering will give an indication of the total consumption during the metering period. This period is generally monthly for municipal supply accounts.

An alternative to metered consumption records would require the installation of electronic logging equipment. This equipment records the rate of flow of water through the incoming supply. Logging equipment may be installed onto certain existing water meters, but recent investigation by the researcher has shown that meters fitted more than 15 years ago may not necessarily be equipped for “pulse metering” by the logging equipment. This would require meter replacement to be carried out by the local authority, at great expense to the school. Logging may also be carried out directly on the incoming mains, by attaching ultra-sonic sensors to a suitable straight length of exposed pipe. The accuracy of this logged flow data would be influenced by the wall thickness of the pipe, corrosion and sedimentation within the pipe, pipe diameter and the position of the sensors in relation to bends and tees causing turbulence within the normal flow of water through the pipe. Logging of water flow, in the latter case, is a costly exercise, yielding data of undetermined accuracy, given the factors noted above.

For the purpose of this study, data will be gathered from supply authority utility accounts. Careful note will be taken to identify those accounts that have been based on provisional assessments of consumption, due to faulty metering equipment, or shortages of meter-reading staff within the local authority. It should be noted that the Rand Water study (McKenzie, Wegelin & Meyer 2002) found that meter readings were available for 43 out of 75 schools in their sample, as a result of missing, vandalised or faulty meters on site. The implications for this project are that the sample may be reduced by 43% due to poor metering.

1.8 Definition of terms

The following terms will be used during the documentation of this research project:

Learner Full-time Equivalent is a measure of the population of a school, measured in terms of the number of full-time learners at the school during a normal school day. Facility use by the community for meetings, sports activities and commercial activities, will be measured using the community population and duration of occupancy, converted to equivalent full-time learner days. Conversion factors have been derived, applied and listed in this report.

Water use, water demand and **water consumption**, contrary to the definitions offered by Bekker (1982), will be used interchangeably to describe the gross volume of water passing through the metered supply of the school, plus, where appropriate, the total volume of extraction from boreholes supplying the school site.

Water-consuming processes will be deemed to include all ablution activities, teaching activities, cleaning, fire fighting, catering, laundry processes, irrigation and water cooling within air-conditioning installations.

Water losses are deemed to include leakages from water installation fittings, leakages from reticulation networks on site, over-irrigation of landscaping and sports grounds, water theft and vandalism of fittings and pipe work.

Sports facilities, when evaluated as a part of the site inspection process, include only grassed sports fields and swimming pools, located within the school premises, which demand water, from metered main or borehole supplies to the site.

Landscaped gardens and lawns, when evaluated as a part of the site inspection process, will include only planted gardens and grassed areas which are regularly watered using formal irrigation systems.

Section 21 schools are schools that are self-governing in terms of the South African Schools Act (1996). These schools prepare and manage their own financial budgets and administer school fees to offset costs incurred in the operation of the school. Utility accounts are paid by the School Governing Bodies of these schools, from the pool of monies received from Departmental funding and school fee collections, fund raising and sponsorships. Utility cost savings would directly benefit the school financially.

Non-Section 21 schools are administered by their School Governing Bodies, with all financial management being carried out by the Provincial Department of Education. Utility cost savings would therefore accrue to the school's account with the Department.

Public schools are schools that are owned and administered by the Provincial Departments of Education.

Independent schools or "Private Schools" are privately owned and administered, within the parameters of the South African Schools Act and other relevant legislation.

1.9 Assumptions

The following assumptions support the interpretation of school water use data:

School population will be considered as static, based on the "tenth day enrolment" figure available from the school administration. The "tenth day enrolment" is an enumeration of the number of learners enrolled at the school on the tenth school day of the school calendar for the year. Whilst the researcher acknowledges that the total number of learners attending school at any one time will vary, due to migration, illness, learner reliability, transport and other factors, the "tenth day enrolment" will provide a consistent measure for comparative assessment of school populations.

A **Normal school day** will be assumed to include normal teaching activities from 07h30 until 13h30, Monday to Friday, during those days listed by the National Department of Education as official school days. Certain independent schools may operate on school calendars differing from public schools. The data from these schools will be normalised to public school days for comparative assessment of school water use.

Desktop assessments of **potential water savings** will be based on the continued utilisation of facilities without change in patterns of behaviour of the users. It should be borne in mind that the educational process aligned with any water conservation initiatives within the schools may positively affect the water use habits of users. These changes would only be assessed after implementation of actual interventions, outside of the scope of this project.

1.10 Importance of this study

Schools throughout South Africa, as with many other institutional facilities, are becoming increasingly pressured to reduce operating costs. Environmental management is the responsibility of every school governing body. This study, whilst reinforcing the need for water use management within these schools, provides a structured approach for these schools to establish a water use model for their own facilities. Practical interventions, available to school management, are illustrated relating water conservation to cost savings and the preservation of water as a scarce national resource, assisting non-technical school managers to identify possible applications within their schools.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

A comprehensive literature review was carried out using the printed and on-line resources of the CSIR, University of Pretoria and the internet. Literature reviewed during this study may be subdivided into the following focal areas:

- National and regional issues relating to security and sustainability of water resource;
- Legislative and statutory documentation;
- Water consumption, patterns of use and consumption by domestic users, and installation appliances;
- Research findings based on studies of water consumption in educational facilities;
- Water conservation initiatives aligned with the domestic / educational water user.

2.2 National and regional issues relating to security and sustainability of water resource

The Department of Water Affairs and Forestry (2002) identifies irrigation agriculture as the major South African water user, consuming around 60% of the national water use. Domestic and urban consumption accounts for 11%, mining and large industries 8% and commercial forestry 8%.

Chapman (1997) observes that during the 1980's, full dams would sustain South Africa with water for a seven-year period, whereas by the end of the 1990's, this period had reduced to three or four years. A reduction of 10% in "unaccounted for" water could extend these reserves by up to a year.

Water losses have plagued municipal engineers for centuries. Chapman relates how water losses in London, England, accounted for about 50% of the water pumped into supply mains, requiring a concerted effort in restraining water users' consumption in order to meet water demands. Chapman continues that scientist and explorer Wendell Philips once remarked that the Queen of Sheba lost her rich kingdom due to the failure of the Yemen water reticulation system, resulting from poor maintenance and leakages.

Water saving, or conservation initiatives, can also reduce the potential for water saving during times of water shortages. "Demand hardening", described by Chesnutt et al (1997) as a "cost" only during times of water shortage may change the perspectives of intermediate water supply authorities to water conservation initiatives. The primary water supplier, in our case the Department of Water Affairs and Forestry, would not consider demand hardening to be of any consequence during water shortages. However, the water distribution boards may be concerned about the allocations of water during shortage periods, and the sensitivity of their consumer base to short term demand management interventions.

2.3 Legislative and statutory documentation

2.3.1 Legislation relating to water resources

Legislation is a basic requirement for the implementation of a national water management strategy.

The current legislative framework, relating to the National Water Resource, is summarised by the Department of Water Affairs and Forestry (2002), as illustrated below:

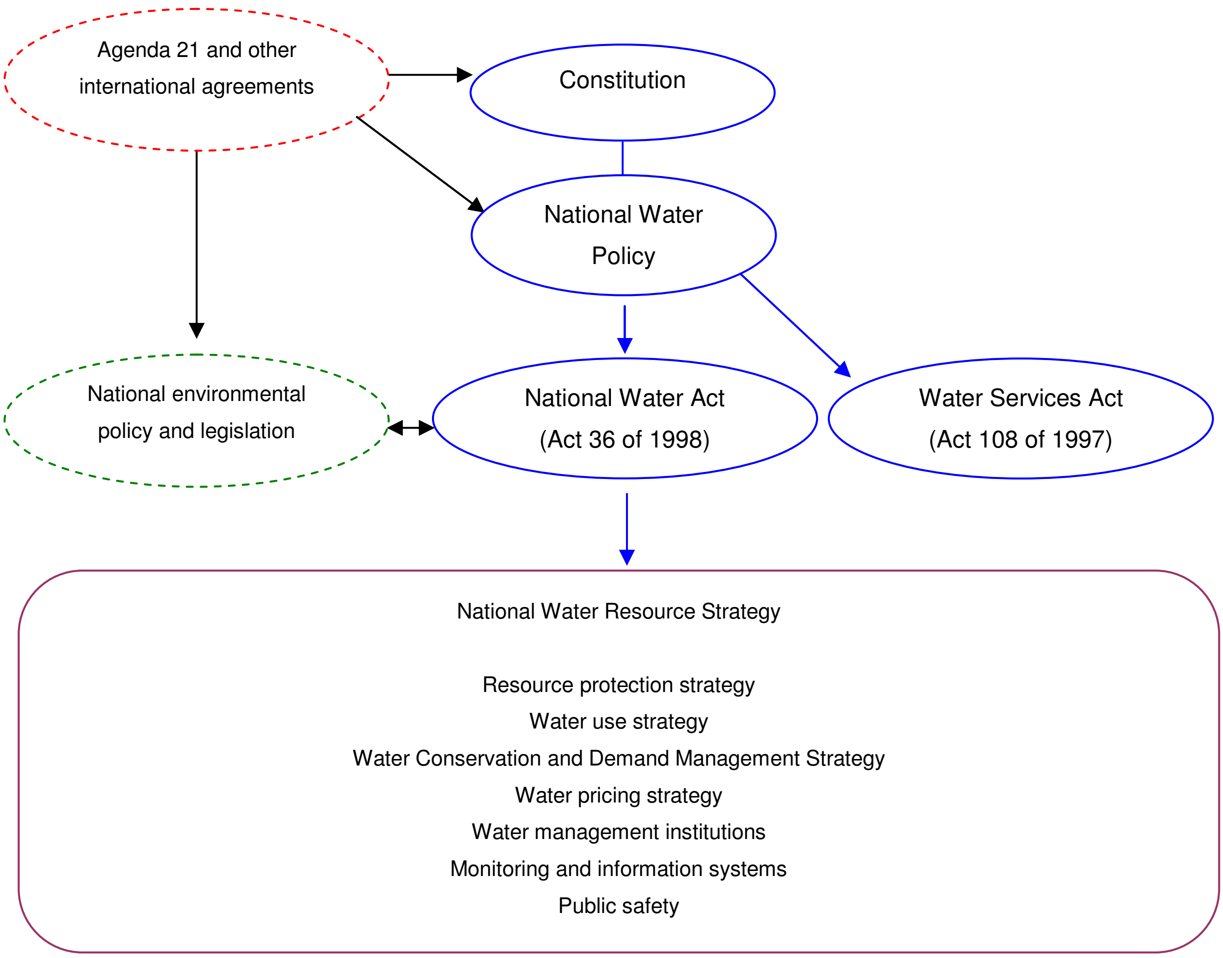


Figure 1: National water legislative structure

2.3.1.1 National legislation

The National Water Act (Act 36 of 1998) deals with the management of water resources, to ensure that there will be water for current and future basic human needs and economic development.

Regulations relating to compulsory national standards and measures to conserve water - The Minister of Water Affairs and Forestry has under sections 9(1) and 73(1)(j) of the Water Services Act, 1997 (Act No. 108 of 1997), made the regulations which were published on 20 April 2001. These regulations include specific requirements, such as:

- By definition “water efficient device” means any product that reduces the excessive use of water.
- Minimum standard for basic water supply services is –
    - the provision of appropriate education in respect of effective water use; and
    - a minimum quantity of potable water of 25 litres per person per day or 6 kilolitres per household per month -
        - at a minimum flow rate of not less than 10 litres per minute;
        - within 200 metres of a household; and
        - with an effectiveness such that no consumer is without a supply for more than seven full days in any year.
- Quality of water, use of effluent and disposal of grey water;
- Monitoring of unaccounted for water and leakage repairs;
- Installation of metering of all users within 2 years (consumers exceeding 60 litres / minute);
- Limiting of supply pressure to 900kPa.

The Department of Water Affairs and Forestry have developed **Model By-Laws** for adaptation and adoption by local authorities. These model by-laws make broad reference to water efficient installations in clause 50(4) ‘A consumer shall ensure that any equipment or plant connected to his or her water installation uses water in an efficient manner.’

Certain municipalities, such as Johannesburg, have completed this process and these by-laws are now in effect. The **Johannesburg by-laws** make additional specific reference to water installation components, including flow rates of showerheads, cistern flush volumes, replacement of automatic flushing urinals and recycling of water in commercial laundries and carwash facilities.

The Water Services Act (Act 108 of 1997) provides the right of access to basic water supply and sanitation. The Act deals with the provisioning of services by the municipalities and bulk supply authorities, to domestic and industrial consumers.

The National Water Resource Strategy will be implemented in a phased process, during the next 20 years. The first edition of the strategy will span a five-year period, including public participation, comment, review and implementation of the various sub-strategies.
While describing the National Water Resource Strategy, the Department of Water Affairs and Forestry (2002) states - "We are not rich in water. Our water resources face growing demands and threats. In the past, water was not allocated fairly. Water is often wasted.
Therefore, the Department has set goals for water management to lead to a better water future:

- Making sure that there is enough water for basic human needs;
- Making sure that the natural environment is protected;
- Making sure that everyone has equal access to water;
- Making sure that water is not wasted and that it is used efficiently;
- Making sure that there is enough water for the future, for a healthy economy and a prosperous society;
- Making sure that everyone pays their fair share for the cost of water that they use, in other words that there is equity in payment for water;
- Honouring our obligations to our neighbours, Lesotho, Swaziland, Mozambique, Zimbabwe, Botswana and Namibia."

National Environmental Management Act, 1998 (No. 107 of 1998) (NEMA)
Water resource management is subject to the requirements of national environmental legislation, that is, the National Environmental Management Act, 1998 (No. 107 of 1998) (NEMA) and those parts of the Environment Conservation Act, 1989, (No. 73 of 1989) (ECA) which have not yet been repealed by NEMA.

2.3.1.2 National standards

Standard	Description	Approved
SANS 10252-1 / SABS 0252-1:1994 - Water supply and drainage for buildings Part 1: Water supply installations for buildings	Establishes general principles for the design, installation and testing of water installations. Does not apply to water installations related to air-conditioning systems, industrial processes, specialized plants (including water softening plants), high temperature (exceeding 80 ¦C) water heating systems, and automatic sprinkler installations.	1994-01-10
SANS 10252-2 / SABS 0252-2:1993 - Water supply and drainage for buildings Part 2: Drainage installations for buildings	Establishes general principles for the design, installation and testing of sanitary drainage installations. Does not cover any special requirements for drainage installations in health care, laboratory or industrial buildings.	1993-12-06
SANS 10254 / SABS 0254:2000 - The installation, maintenance, replacement and repair of fixed electric storage water heating systems	Details the safe installation of new and replacement fixed electric storage water heaters complete with all the relevant and applicable safety and hydraulic control units. Covers the maintenance and repair of the storage water heating system.	2000-12-18
SANS 10400 / SABS 0400:1990 - The application of the National Building Regulations	Covers provisions for building site operations and building design and construction that are deemed to satisfy the provisions of the national building regulations. In certain cases, commentary and illustrations to amplify and explain the application of the deemed-to-satisfy rules are included. Information on standardization of the application of the regulations is contained in a commentary to Part A of the regulations.	1990-08-23 National Erratum: 1990-08-01 National Corrigendum: 1996-05-22

2.3.1.3 Draft national standards

SANS 10323 - Grey water recycling - Currently in stage 30.20 - Circulation of committee draft (CD) for comment (since 2000-11-08). Target date: 1998-06-30. Committee no. 5120.12

2.3.1.4 Other standards

Joint Acceptance Scheme for Water-Services Installation Components (JASWIC)
The JASWIC Committee maintains a list of acceptable components. Criteria that should be applied when considering applications have been determined. As a result, all the existing SABS and other relevant specifications have been reviewed. For components where no current specifications exist, basic evaluation criteria have, or are being developed, for use by the Committee and the SABS, for carrying out acceptance tests. These “R-requirements” are meant to be temporary, until the SABS can develop a suitable National standard specification.

Rice & Shaw (1978) report the City of Dallas’ approach to water conservation was based on:

- strong public information and educational programmes; and
- federal performance standards for water use to apply to water intensive industries and products.

2.3.2 Legislation relating to schools

A number of policies have been implemented and legislation implemented within education. These include:

- **The South African Constitution (Act 108 of 1996)** requires education to be transformed and democratised encompassing values of human dignity, equality, human rights and freedom, non-racism and non-sexism. It guarantees access to basic education for all, with the provision that everyone has the right to basic education, including adult basic education.

- The fundamental policy framework of the Ministry of Education is incorporated into the Ministry’s first **White Paper**: Education and Training in a Democratic South Africa: First Steps to Develop a New System (February, 1995). This document adopted as its point of departure the 1994 education policy framework of the African National Congress.

- **The National Education Policy Act (NEPA) (1996)**, was designed to implement law through policies, formalise the relationship between national and provincial authorities, and laid the foundation for the establishment of the Council of Education Ministers (CEM), as well as the Heads of Education Departments Committee (HEDCOM), as inter-governmental forums to collaborate in developing a new education system. It provides for the formulation of national policies for curriculum, assessment, language policy, as well as quality assurance.

- **The South African Schools Act (SASA) (1996)**, promotes access, quality and democratic governance in the schooling system. It ensures that all learners have right of access to quality education without discrimination, and makes schooling compulsory for children aged 7 to 14. It provides for two types of schools - independent schools and public schools. The provision in the Act for democratic school governance through school governing bodies is now in place in public schools country-wide. The school funding norms, outlined in SASA, prioritise redress and target poverty with regard to the allocation of funds for the public schooling system.

Other Education related legislation includes:

- Further Education and Training Act (1998);
- Education White Paper 4 on Further Education and Training (1998);
- National Strategy for Further Education and Training (1999-2001);
- Higher Education Act (1997);
- Education White Paper 3 on Higher Education (1999);
- National Plan for Higher Education (2001)
- Employment of Educators Act (1998);
- Adult Basic Education and Training Act (2000);
- South African Qualifications Authority (SAQA) Act (1995);
- Curriculum 2005 (C2005);
- Education Laws Amendment Bill (2002)
- Higher Education Amendment Bill 2002

The SASA requires the establishment of school governing bodies (SGB's) within schools. The SGB is tasked with the compilation of a School Development Plan and policies for the management of the school, including financial and environmental management.

The development of these policies is guided by 'Guidelines to School Governing Bodies: Developing Policy for Public Schools', published in Gauteng by the Provincial Department of Education on 5 July 2002.

2.4 Water consumption, patterns of use and consumption by domestic users, and installation appliances

Konen & Stevens (1986) have developed a predictive water use model for water consumption in office buildings. The model is summarised below:

Male Water Use, MWU:

$$MWU = POP \times \frac{RRU}{POP}\left[\frac{WCU}{RRU} \times \frac{VOL}{WCU} + \frac{URU}{RRU} \times \frac{VOL}{URU} + \frac{LAVU}{RRU} \times \frac{VOL}{LAVU}\right]$$

Female Water Use, FWU:

$$FWU = POP \times \frac{RRU}{POP}\left[\frac{WCU}{RRU} \times \frac{VOL}{WCU} + \frac{LAVU}{RRU} \times \frac{VOL}{LAVU}\right]$$

Where:

POP = Population (number of males / females in the user group);

$\frac{RRU}{POP}$ = Rest room water uses per person per day;

$\frac{WCU}{RRU}$ = Water closet uses per rest room use;

$\frac{VOL}{WCU}$ = Water efficiency of water closet (litres / flush);

$\frac{URU}{RRU}$ = Urinal uses per rest room use;

$\frac{VOL}{URU}$ = Water efficiency of urinal (litres / flush);

$\frac{LAVU}{RRU}$ = Lavatory (wash basin) uses per rest room use;

$\frac{VOL}{LAVU}$ = Water efficiency of lavatory (wash basin) (litres / use);

The study identifies important information relating to frequency of use in the office environment:

	Male	Female
Water closet uses per rest room user	0.33	0.96
Lavatory (wash basin) uses per rest room user	0.96	0.96
Urinal uses per rest room user	0.67	0.00
Rest room uses per person per day	2.18	3.08

Rump (1979) estimates the proportional use of water in a London office building as:

WC flushing	43%
Washing	27%
Urinal flushing	20%
Canteen use	9%
Cleaning	1%

Stone (1978) reports, from findings of the California Department of Water Resources, that more than 75% of domestic consumption may be for external (irrigation) use during maximum day conditions (hottest weather). This estimation correlates closely with estimates calculated by Tondut (1976) in an analysis of 111 domestic facilities in northern Perth, Australia. Tondut reported a range of exterior water use from 67% - 85% (the latter during the hottest months).

Oliver (2002) identified the major selection criteria used by South African architects, for the selection of water installation components. Familiarity with the manufacturer, the product and the application were overwhelmingly favoured over water saving potential of the components of the water installation, as illustrated in Figure 2. This tendency would suggest that existing, and new, school designs would most likely not contain water saving equipment within the water installation, but rather that equipment which has become familiar to school designers and specifiers.

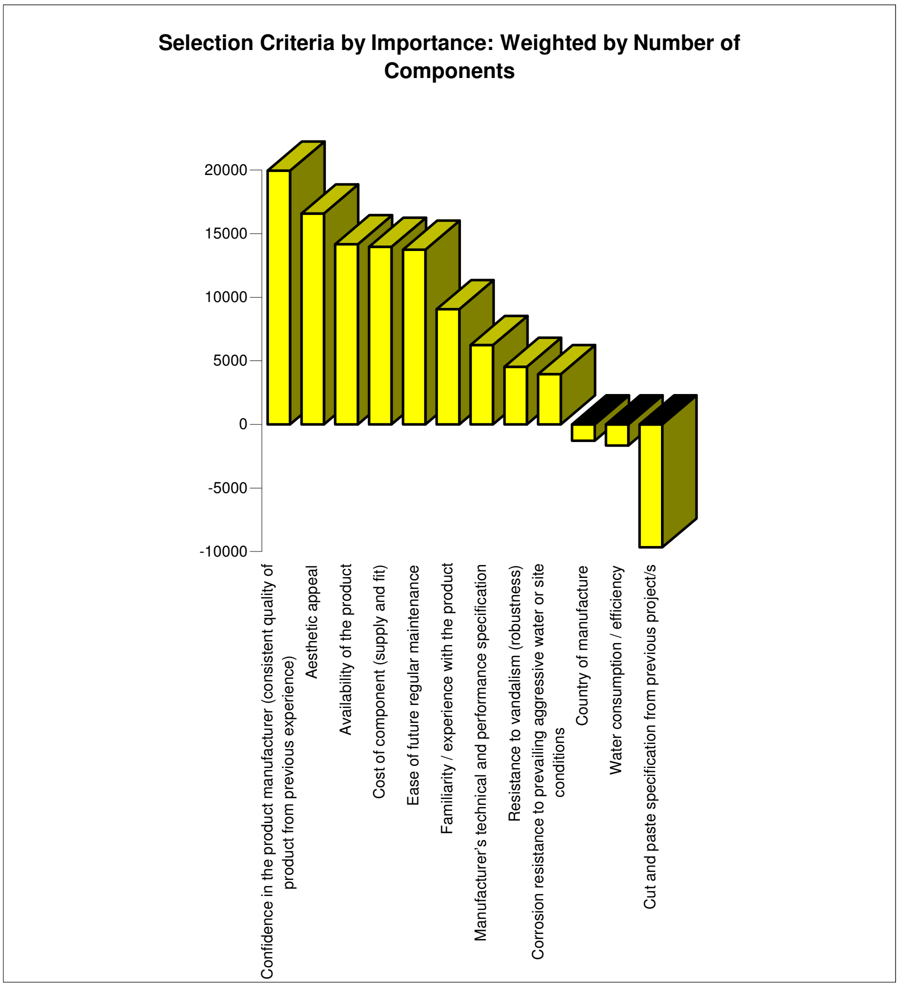


Figure 2: Current practice in the specification of water installation components by South African architects

2.5 Research findings based on studies of water consumption in educational facilities

Very little documented evidence exists of water use studies carried out in South African schools.

Urban Management (1997) describes a recent water audit carried out at the Westville Primary School in Mitchell's Plain, Western Cape Province, identifying a water use of 21 500 litres per day in automatically flushing urinals. An installation described in the Hermanus Primary School, is providing the school with estimated water savings of 5 million litres per annum. The intervention included installation of push button modifications to the automatic flushing urinals on the school site. No financial information is provided in the study.

McKenzie, Wegelin & Meyer (2002:pp.3-1 to 3-16) describe projects carried out by Rand Water, in retrofitting certain installation components at schools in Boksburg (48 schools) and Kagiso (Krugersdorp) (27schools). The project involved retrofitting of push button flush valves to automatic flushing urinals, dual flush mechanisms to WC cisterns, replacement of taps with push button demand taps, and fitting of low flow showerheads. During the project several leaking pipes were identified and broken installation components replaced. Resultant savings of 31 to 44% on metered consumption are reported. The project reports the following lessons learned:

- Vandalism was significant. The school (learners and staff) should be involved with the retrofit and management of the installation to avoid such occurrences.
- Water metering is required to be in place before the commencement of the retrofit since without water use data, savings cannot be verified. Many meters are found to be inoperative;
- Quality control of installation work should be carried out by a third party;
- An integrated social development programme is required to uphold efficient water use projects, educate learners and users, and provide a sustained reduction in water use;
- Maintenance personnel are a key link in the water conservation chain;
- Procurement of local services for retrofitting requires business management support.

An investigation into water use in Canadian Day Schools (Robson 1966) was carried out to provide the Nova Scotia Department of Health with revised planning norms for the provision of water services to schools. Nine schools were sampled, measuring water consumption and, to a limited extent, water demand patterns. Water records for a two-year period were analysed for each school and school staff recorded daily meter readings for three two-week periods. Records of school attendance were obtained from the schools. The results indicated the following:

- There was a small difference in the water use during the school day to a full 24 hour use;
- Automatic flushing urinals were identified as the cause of major water wastage;
- Regular washing of the four school buses at one school significantly influenced consumption figures;
- Lack of maintenance of taps and valves was another major cause of wastage;
- Water consumption ranged from 10 to 33 litres per pupil per 24-hour day (average for a year period), with an average of 21 litres per pupil per day.

British schools have been shown to consume approximately 3,8 m^3 of water per learner per annum at primary schools without swimming pools, and 3,9 m^3 at secondary schools without swimming pools.
These figures cannot be satisfactorily compared, since the numbers of school days in each country are not given.

2.6 Water conservation initiatives aligned with the domestic / educational water user

"The domestic use of water can be reduced in many ways without lowering living or health standards or unnecessarily burdening consumers. It must however be brought home to every user that, even though squandered water can be reclaimed, reclamation involves additional capital outlay and running costs. Substantial savings can be effected by modifications in toilet facilities, improved water use methods, elimination of leakage, pressure and flow regulation and effective metering of all consumers' establishments." (Crabtree 1978)

Crabtree (1978) also reports that the United States Department of Water Resources advised the use of water efficient devices, some through the enactment of legislation as early as 1976. Projected water savings, as a percentage of domestic interior water use were:

Low flush toilets	18%
Low flow showers	12%
Low flow basin taps	2%
Pressure reducing valves	5%

Chapman (1997) contends that the reduction of supply pressure, from 9 bars to 5 bars, would result in the loss of water through a defect in a pipe by more than 50%.

Initiatives of the California Department of Water Resources, reported by Stone (1978), have identified the following physical water use suppression methods, and their respective effectiveness:

- Installation of meters can suppress demand by 25 – 58%. This presumes that the user becomes liable for the actual cost of water consumed;
- Pressure regulation. Reduction in pressure from 500 – 835 kPa down to 350 kPa resulted in savings of 16 to 24%. These figures are substantially lower then those stated by Chapman above.
- Flow restrictors fitted at the incoming meter could reduce peak demand;

- Service diameters could be used to reduce peak demand flows. The following flow rates are estimated at 350 kPa:
  - 12mm diameter copper pipe 1 litre / second
  - 19mm diameter copper pipe 2 litres / second
  - 25mm diameter copper pipe 4 litres / second
- Hose meters and timers fitted to irrigation systems by up to 20%. The project showed that 78% of parks and recreational facilities were over watered.
- Moisture sensors, landscape design and planting materials could also reduce water use.

2.7 Summary

Current South African legislation and standards have clearly established a framework for the promotion of water conservation in all sectors of the economy, supported by various activities within the Department of Water Affairs, as well as the various regional water authorities and local authorities.

A number of models have been developed by overseas agencies to estimate water consumption in office buildings, and similar developments. Local initiatives, aimed at schools, have implemented technology upgrades and maintenance activities, in order to reduce water consumption within schools indicating high water consumption.

Internationally, governmental institutions have widely promoted the use of water efficient technologies in the construction of new and refurbished facilities.

Given the above information, the following chapter describes how this study will proceed to gather and analyse pertinent information and water consumption data from a sample of South African schools.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The successful completion of this research task requires that an extensive survey be carried out of water consumption in schools. Linked to the gathering of data describing consumption of water in these schools, will be the identification of processes within which water is consumed, and the identification of key indicators describing the extent of school activities, populations and infrastructure.

Engagement with schools required the integration of the various national and provincial departments of education to be introduced to the study, through presentations and interactive discussions, as well as the goodwill of local school management, providing personnel and valuable time to assist with data gathering.

3.2 Stakeholder engagement

3.2.1 National and provincial departments of education

This project was reliant on the collection of water use data, process identification and physical inspection of a sample set of schools. In order to gain access to these schools, the cooperation of the Department of Education was required. Obtaining written permission from the Department to enter and inspect schools required interaction with numerous role-players:

- Approach to the Director: Physical Planning, National Department of Education, Pretoria, with written submission of the project outline and process to be followed;
- Written introduction from the Deputy Director General, Schools Provisioning, to the appropriate provincial Education Head of Department;
- Identification of an appropriate sample set of school to be visited. Due to financial constraints, the sample was limited to schools in Gauteng North region;
- Written introductions from provincial Heads of Department to the District Manager and school principals, requesting their cooperation in the data collection and inspection process within targeted schools.

3.2.2 School management

After selecting a suitable sample of schools, site visits were planned by grouping these into precincts, allowing easy and cost-effective access by auditing teams. Based on these scheduled visit dates and times, appointments were made with school principals to facilitate the task of the audit teams.

Pro-forma letters of introduction were compiled and dispatched by fax to each school. The school principals were requested to acknowledge receipt by signing and faxing back a reply slip. This was found to be useful in determining whether the schools had prioritised the audit visits as requested. In many cases the school fax details, extracted from the SRN2, were out of date, or out of order. This necessitated contacting those schools by telephone, to arrange the visit.

3.3 School facility definition

Logically, resource consumption and waste generation within the facility relate directly to the "personality" of the school facility. This relationship is illustrated in Figure 3.

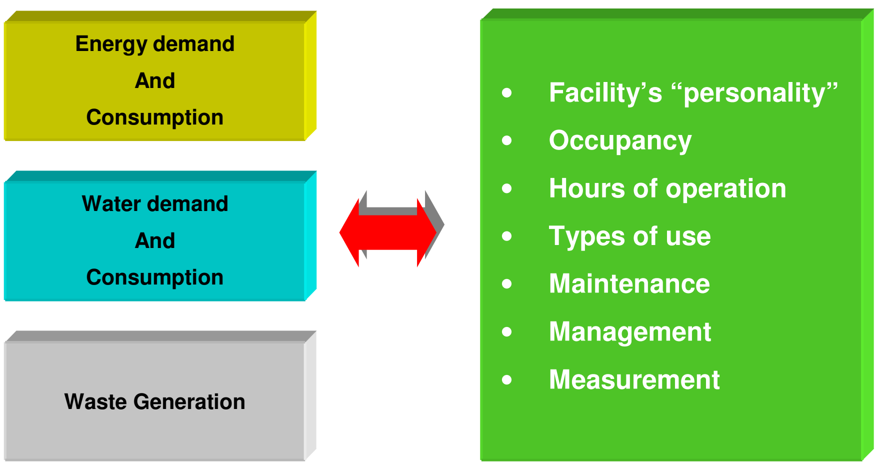


Figure 3 - Relationships between resource consumption, waste generation and facility

The school's personality is constructed of a number of elements, including:

- **Occupancy** – since occupants are directly served by the facility, and their activities within, and use of the facility will directly affect the resources consumed in meeting their demands;

- **Hours of operation** – related to occupancy; describing the duration of the demands imposed on the facility by facility occupants;
- **Types of use** – within schools, this would imply use of art rooms, laboratories, ablutions, change areas and showers, classroom activities and administrative activities, each introducing resource demands specific to the activity;

- **Maintenance** – determines potential water loss due to malfunctioning water installation equipment. Poor maintenance may cost many litres of wasted water from leaking taps, leaking cisterns, urinals and pipe work, above or below ground;

- **Management** – including inspection protocols within the school, and facility management operation. Frequent inspection, simple reporting procedures, and well-managed budgets facilitate maintenance and require regular reporting to administrative management. Management would also include the payment procedures followed for the payment of utility accounts, whether with, or without sight of the facility management personnel;

- **Measurement** – is required to be undertaken as a regular function of facility management, not only to verify monthly utility accounts, but to monitor usage on a regular (daily or weekly) basis. This allows losses by undetected leakage to be identified before the school incurs large costs. Measurement, however, presupposes the existence of operational, and accurately calibrated, metering devices within the mains supply to the school. Many schools are not fitted with such metering, and many meters fitted to schools are not fully operational.

A graphical representation of the water installation and major uses is shown in Figure 4:

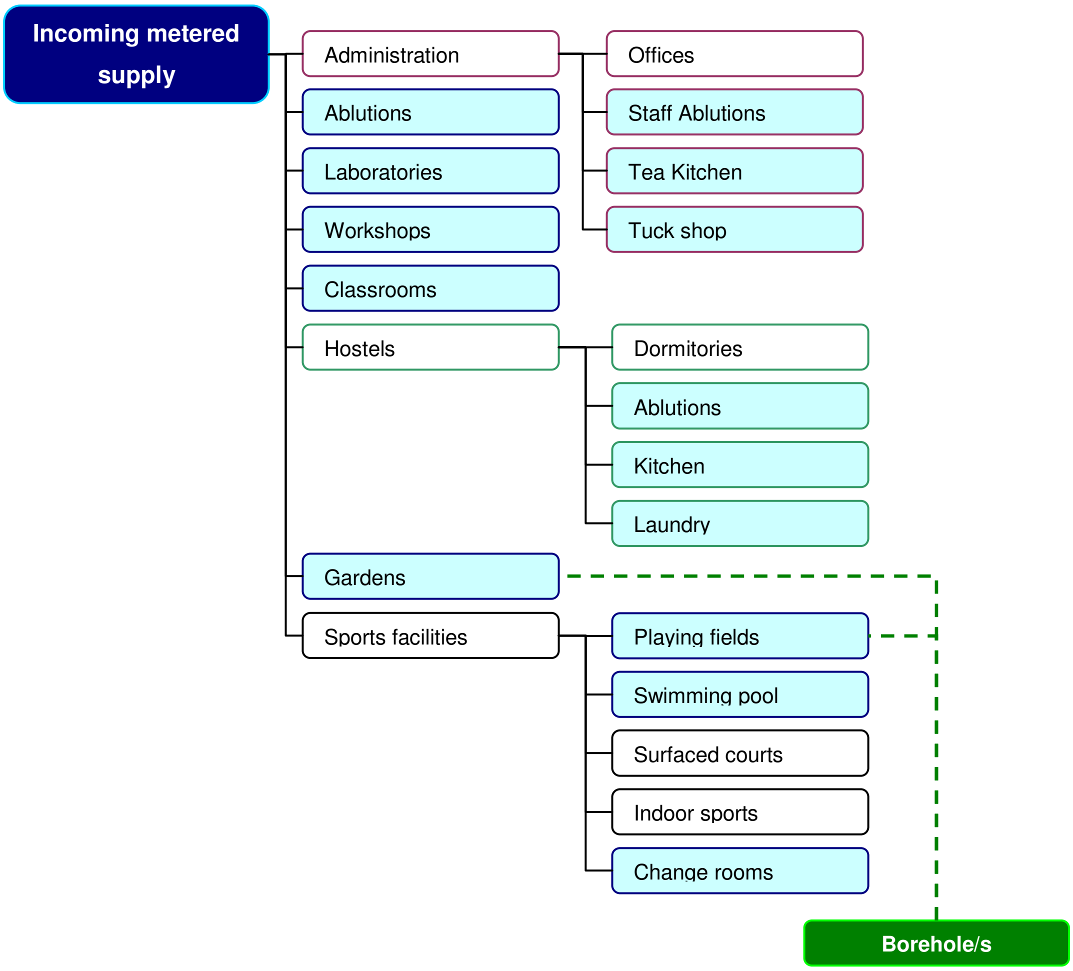


Figure 4: Map of facility water use

3.4 Process definition within schools

School operations were observed during normal school hours, after teaching hours, and during weekends. The major school processes are illustrated in Table 1, showing water consuming elements of these processes (shaded in light blue).

Processes occurring in a school

(without hostels and on-site staff accommodation)

Administration		
Secretarial	Reception	Catering
Duplicating	Finance	Ablutions
Storage	Managing	Cleaning

Teaching		
Preparation	Chalkboard	Demonstration
Storage	Cleaning	Experimentation

Breaks		
Ablutions	Refreshments	Cleaning

Sport - Participation		
Playing	Changing	Showering
Ablutions	Refreshments	Cleaning

Sport – Support		
Ablutions	Refreshments	Cleaning
Observation	Cooking	

Grounds keeping		
Irrigation	Tending	Mowing
Fertilizing	Planting	Marking
Washing down	Sweeping	

Table 1: Processes occurring in a school

3.5 Key performance indicators

Key performance indicators may be constructed at various levels of granularity, from broad facility level, to specific process level within the school. For the purposes of this study, only facility level key performance indicators (KPIs) have been identified, since finer granularity would require the installation of sub-metering equipment by the schools, at high capital cost.

Figure 5 - Various levels of KPI leading to performance improvement

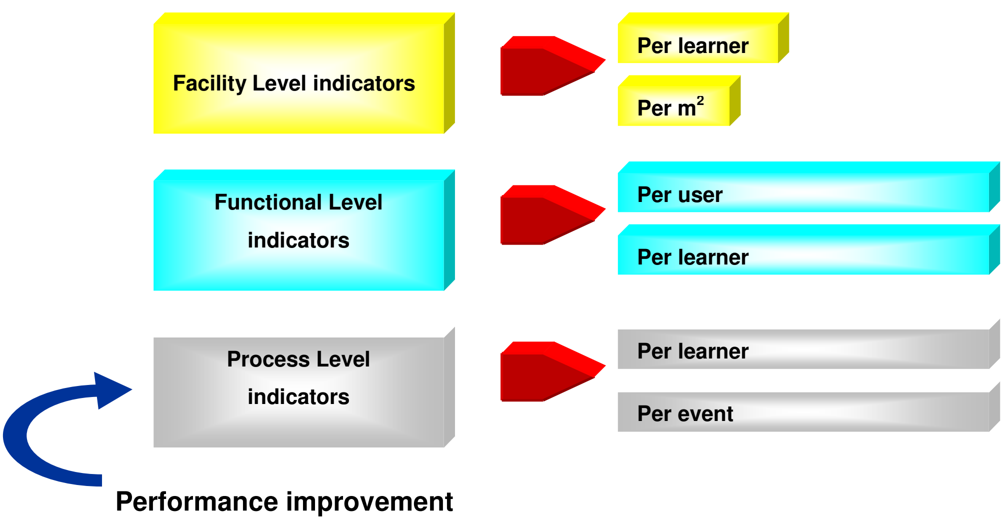


Figure 5 illustrates the progressive definition of key performance indicators, from coarse "facility" level to a much finer "process" level. Managing facility performance at process level enables facility management to implement performance improvement within the facility, since interventions can only be applied at process level. The measurement and monitoring of outcomes of interventions should therefore also take place at process level, by management, to allow accurate monitoring of these outcomes.

3.6 Data collection process

Data collection took place in a number of phases, accessing data from various data sources, as follows:

3.6.1 School facility data

Identification of a suitable sample set of schools, with a view to detailed facility data collection, site visits and inspections made use of the National Department of Education's Schools Register of Needs, Version 2 (SRN2), released during 2000. The SRN2 contains a listing of all schools registered with the South African National Department of Education, and includes data describing the geographic locality of the school, in terms of province, region and district, the school population, in terms of learners and staff, and various attributes relating to the physical facilities, such as the nature of electricity and water supplies.

Budgetary constraints on this project required the sample set to be limited to the Gauteng North Region, as identified by the Departments regions "N1" to "N7" within the province "GT", as described within these specific fields within the SRN2 dataset. The SRN2 dataset contains 761 schools within this defined subset.

Since the focus of this project is on water use, using metered consumption as a basis for analysis, only those schools with metered utilities were considered for the sample. The SRN2 contains 484 such schools within the GT N1 – N7 subset.

Constrained by financial limitations, a selection of 100 schools was targeted to be visited for in-situ inspection and auditing. The systematic sample, listed in Appendix A, was derived by sorting the GT N1 – N7 subset of schools, with metered utilities, into order of total learner enrolment, then selecting every fifth school in this ordered list.

Field teams of one and two persons, from within the CSIR: Boutek's Facilities Planning and Management Programme were assigned to site visits. Visits were planned to be carried out in precinct groups, to minimise travelling costs and time. Cognisance was also taken of the prevalence of languages in the audited precincts, with teams, fluent in the appropriate languages, allocated to these precincts.

Prior contact was established with the targeted schools, by fax (See Appendix E). Telephonic confirmations of visits were made the day before each site visit, where possible.

Field teams gathered audit data using a questionnaire, developed using guidelines provided by the University of Pretoria's Department of Statistics: Research Assistance Department's Mrs Elana Mauer. The data collection instrument is attached in "Appendix B: Site audit questionnaire". The data collection process consisted of the following:

- Interview with the school principal, or appropriate member of the school executive, in order to introduce the project, the field team and to outline the contents of the data collection instrument;

- Interaction with the school administrator, or school secretary, to obtain enrolment data, copies of utility accounts, and other relevant facility data;

- Physical inspection of the facility, accompanied by the school caretaker, or grounds man, where available. This inspection included a cursory examination of:
    - Ablution facilities;
    - A selection of classrooms;
    - A selection of laboratories;
    - Sports fields and irrigation equipment;
    - Swimming pool and other sports facilities;
    - Change rooms;
    - Hostels, kitchens and laundry;
    - Water metering equipment.

3.6.2 Pilot testing the questionnaire

Four easily accessible schools were selected and visited to allow for the testing of the audit instrument, as well as the training and calibration of the audit personnel. A few minor, but necessary changes to the audit instrument were effected prior to the execution of the remainder of the audit process.

3.6.3 Schools excluded from the data collection process

The following schools were not visited during the data collection process, for reasons noted against each facility:

Table 2: Sampled schools not visited

No.	Name	Reason
1.	Spartan Primary	Combined with Spartan High School – same premises.
2.	Kgotlelelang Primary	Declined visit
3.	Laerskool Millennium	Declined visit
4.	Cornerstone College Secondary	Declined visit.
5.	Jacaranda Primary	Declined visit.
6.	John Martin Catholic	Declined visit.
7.	Laerskool Die Ruiter	Declined visit.
8.	Loreto	Declined visit.
9.	St Catherine's Convent	Declined visit.
10.	Elite College	Private school in rented premises. No dedicated facilities or accounts.
11.	Anchor Christian Academy	Private school on church premises. No dedicated facilities or accounts.
12.	Hatfield Christian	Private school on church premises. No dedicated facilities or accounts.
13.	Hoërskool Erasmus	Remote location / Farm school / Not supplied by municipality
14.	Jabulani Junior Primary Private	Remote location / Farm school / Not supplied by municipality
15.	Laerskool Nooitgedacht Nr 88	Remote location / Farm school / Not supplied by municipality
16.	Badirile Secondary	Remote location / Farm school / Not supplied by municipality.
17.	Bathabile Primary Farm	Remote location / Farm school / Not supplied by municipality.
18.	Dan Kutumela Secondary	Remote location / Farm school / Not supplied by municipality.
19.	Hoërskool Carletonville	Remote location / Farm school / Not supplied by municipality.
20.	Magaliesburg State	Remote location / Farm school / Not supplied by municipality.
21.	Thathezakho LP	Remote location / Farm school / Not supplied by municipality.
22.	Westonaria Primary	Remote location / Farm school / Not supplied by municipality.
23.	Zakhele Primary	Remote location / Farm school / Not supplied by municipality.
24.	Zamintuthuko Primary	Remote location / Farm school / Not supplied by municipality.
25.	Kholofelo Primary	School is empty – relocated to other premises.
26.	Doxa Deo Christian	Unable to arrange visit. Not visited
27.	Dr Yusuf Dadoo Primary	Unable to arrange visit. Not visited
28.	Isiqalo Primary	Unable to arrange visit. Not visited
29.	Itumeleng Madiba Primary	Unreachable – unable to arrange visit. Not visited.
30.	Lewisham Primary	Unreachable – unable to arrange visit. Not visited.
31.	Mzimuhle Primary	Unreachable – unable to arrange visit. Not visited.
32.	Thuto Lefa Secondary	Unreachable – unable to arrange visit. Not visited.
33.	Tshepisa Primary	Unreachable – unable to arrange visit. Not visited.
34.	Koos Matli Primary	Unreachable– unable to arrange visit. Not visited.

The high incidence of schools not visited, as listed in Table 2, was attributable partially to inaccuracies in the SRN2 data being used to select the sample - twelve of the schools not visited do not obtain water from a local municipal supply, but are supplied from local farm supplies. Many schools were not able to be reached in order to arrange the site visits, due to incorrect telephone and fax information and / or faulty or discontinued telephone services. A number of schools, including a small number of independent schools, declined our visit due to time and resource constraints, or lack of interest.

3.6.4 Water consumption data

Utility accounts for a number of schools were obtained from the Tshwane Metropolitan Council, by arrangement with their accounts department. These accounts were mainly for the Soshanguve region schools, where these schools do not receive accounts directly from the supply authority, but these accounts are posted directly to the Department of Education.

3.6.5 Logging of water use

During the course of this research project, it was discovered that Monument Primary School, one of the sample schools, had employed the services of Messrs SWR Projects cc to undertake a water loss study on their premises. This study was motivated by the high water bills being paid by the school. Messrs SWR Projects kindly made their logged water consumption data available for the purposes of this project. Water use at the school was logged, using electronic data loggers, over a seven day period. The water consumption is illustrated in Figure 6 below.

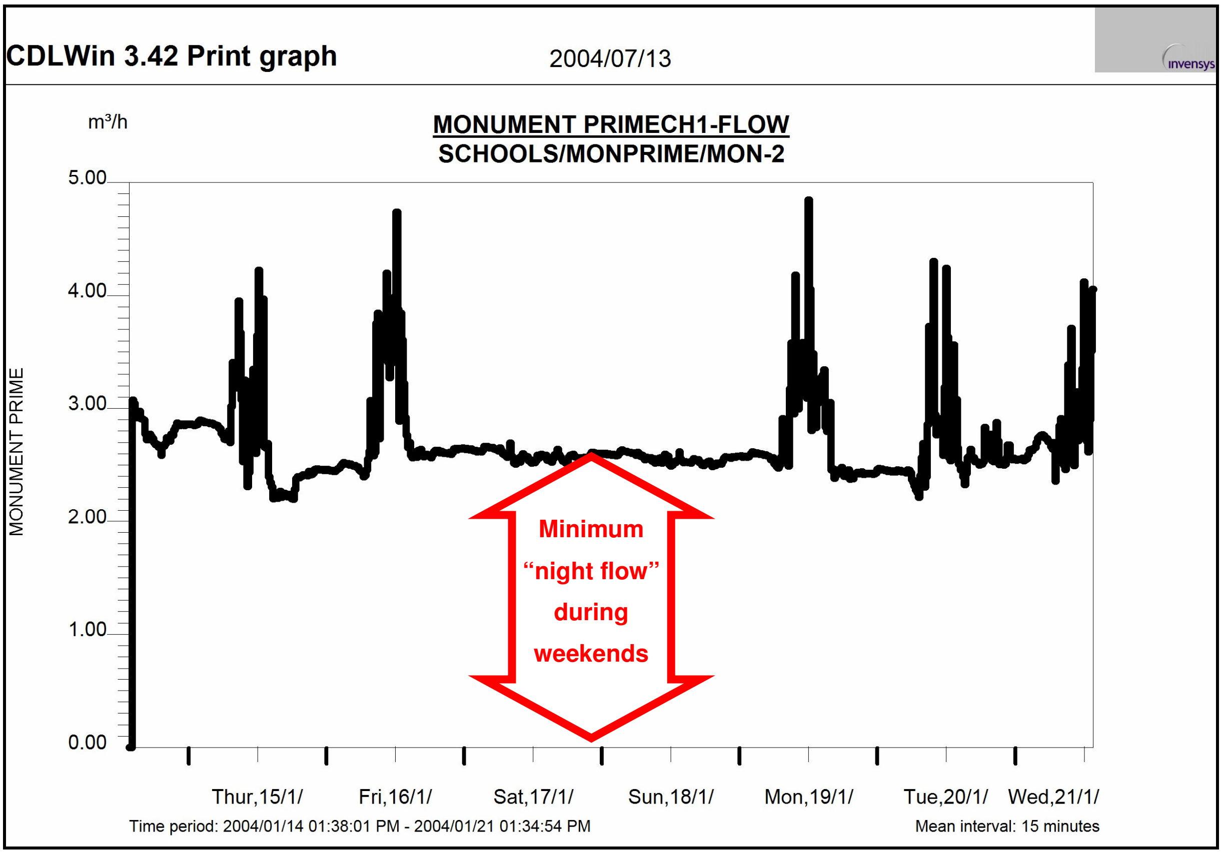


Figure 6: Logging of water consumption: Monument Primary School: 7 day period

The figure clearly illustrates water losses due to consumption during unoccupied hours and over weekends. This graph suggests that water losses during unoccupied periods, or "night flow", amount to approximately 2.5 m3 per hour, or 2 500 litres per hour.

Figure 7 applies a larger scale to the graphed data, illustrating water consumption, and "night flow" during a 24 hour period. Peak usage times may be clearly seen, coinciding with school break times, and school closing time. A drop in "night flow" or minimum flow is observed during the period 07h00 to approximately 19h00, resulting from reduced pressure in the supply mains. This reduced pressure results in a slowing of leakages in the school's reticulation network.

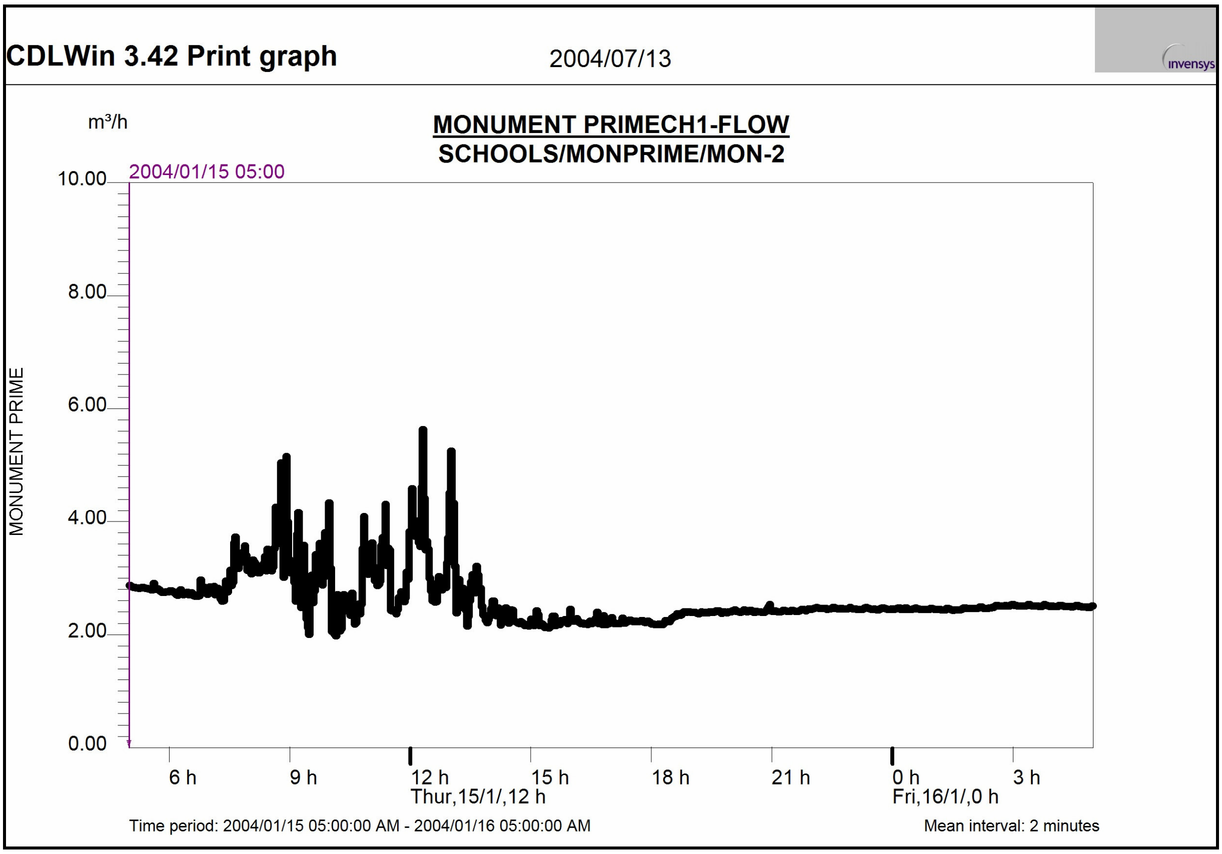


Figure 7: Logging of water consumption: Monument Primary School: 24 hour period

3.7 Summary

This chapter describes the collection of data from a sample set of schools in Gauteng North. The core and supporting processes occurring in these schools were identified for later application within the data analysis phase.

A number of schools from within the sample set were unresponsive, or declined their participation in the study. The large unresponsive group may be attributable to incorrect contact details contained within the SNR2 database, used to originate telephone and facsimile contact numbers.

Having gathered significant volumes of data from the sample set, the next chapter will describe the analysis of this data, towards the construction of a water use model for schools.

CHAPTER 4: DATA ANALYSIS

4.1 Introduction

This chapter describes the detailed analysis of site audit results, obtained from questionnaires and utility accounts gathered from the sample set of schools.

4.2 Calculation of Full Time Equivalent (FTE) population of the school

In order for data collected at various schools to be normalised to a uniform basis, the concept of Full Time Equivalent (FTE) has been used. For the purposes of this study, one FTE is the equivalent of one person (learner, educator or administrative staff member) attending the school, for the normal duration of a school day, from 07h30 to 13h30. All other facility uses will be converted to FTEs to allow uniformly comparative assessments of water consumption to be made.

4.2.1 Normal school activities and after hours use

<u>Weekdays</u>

Mornings:

$$P_{FTE} = (L + S) \times 147$$

where:

L = Number of learners enrolled;

S = Number of staff employed (educators and administration)

Note: There are 147 school days in the current school year.

Afternoons:

Assuming that extra-mural activities occur between 14h00 and 16h00:

$$P_{FTE} = P_{afternoon} \times \frac{2}{6} \times 147$$

where:

$P_{afternoon}$ = Number of people on site during weekday afternoons.

Evenings:

Assuming that evening activities occur between 19h00 and 21h00:

$$P_{FTE} = P_{evening} \times \frac{2}{6} \times 147$$

where:

$P_{evening}$ = Number of people on site during weekday evenings.

Saturday

Mornings:

Assuming that extra-mural activities occur between 08h00 and 12h00:

$$P_{FTE} = P_{sat\_am} \times \frac{4}{6} \times 30$$

where:

P_{sat_am} = Number of people on site during weekday afternoons;

Note: There are 30 school weekends in the current year.

Afternoons:

Assuming that extra-mural activities occur between 14h00 and 16h00:

$$P_{FTE} = P_{sat\_pm} \times \frac{2}{6} \times 30$$

where:

P_{sat_pm} = Number of people on site during weekday afternoons;

Evenings:

Assuming that Saturday evening activities occur between 19h00 and 22h00:

$$P_{FTE} = P_{sat\_night} \times \frac{3}{6} \times 30$$

where:

P_{sat_night} = Number of people on site during weekday afternoons;

Sunday

Mornings:

Church groups often use school facilities as meeting venues. Assuming that these morning activities occur between 09h00 and 11h00:

$$P_{FTE} = P_{sun\_am} \times \frac{2}{6} \times 52$$

where:

P_{sun_am} = Number of people on site during weekday afternoons;

Note: These activities would occur independently of school terms.

Afternoons:

Sunday afternoon activities at school facilities are generally attributable to community sports clubs, and social activities. Assuming that these activities occur between 14h00 and 17h00:

$$P_{FTE} = P_{sun\_pm} \times \frac{3}{6} \times 52$$

where:

P_{sun_pm} = Number of people on site during weekday afternoons;

Evenings:

Assuming that Sunday evening activities are church related, and occur between 18h00 and 21h00:

$$P_{FTE} = P_{sun\_night} \times \frac{3}{6} \times 52$$

where:

P_{sun_night} = Number of people on site during weekday afternoons;

4.2.2 Platoon school population

Platoon schools occupy the host school after normal school hours (afternoons). For the purposes of data analysis, it is assumed that the platoon school population is included into the schedule of facility population provided during the site audit. No additional population will be added to calculations.

4.2.3 Hostel accommodation

School Days:

Hostel boarders will occupy their accommodation during non-school hours. Each hostel day would be considered as 13h30 – 07h30.

Note: This may result in over-counting the boarders who participate in extra-curricular activities after school hours:

$$P_{FTE} = P_{hostel} \times \frac{18}{6} \times 147$$

where:

P_{hostel} = Number of boarders in the hostels during school days;

Weekends:

Hostel boarders are assumed to occupy their accommodation during afternoons and evenings on weekends. There are 30 school weekends in the calendar; each weekend hostel day would be considered as 24 hours, less 4 hours during mornings = 20 hours.

Note: This may result in over-counting the boarders who participate in extra-curricular activities after school hours:

$$P_{FTE} = P_{hostel\_wend} \times \frac{20}{6} \times 30 \times 2$$

where:

P_{hoste_wendl} = Number of boarders in the hostels over weekends;

The data collection instrument identified the presence and level of service of hostel laundries and kitchens. However, due to the limited number of schools in the sample with hostel laundries and kitchens, no conclusive findings could be reached in this study. This may be an area for further research. The tendency at national and provincial Departments of Education seems to be away from boarding schools, towards schools admitting learners from their local feeder areas. The impact of hostel water consumption, on the schools portfolio generally, would tend, therefore, to become insignificant.

4.2.4 Staff housed on site

School days:

Site staff will occupy their accommodation during non-school hours. There are 147 school days in the calendar, each staff housing day would be considered as 13h30 – 07h30.

Note: This may result in over-counting staff who participate in extra-curricular activities after school hours:

$$P_{FTE} = P_{sitestaff} \times \frac{18}{6} \times 147$$

where:

$P_{sitestaff}$ = Number of staff accommodated on site;

Non-School days:

Site staff will occupy their accommodation in an unpredictable routine. Many staff members living on site would be absent from their homes, as well as entertaining guests in these homes, at undefined times. For the purposes of this study, it is assumed that there are 218 non-school days in the calendar, each staff housing day would be considered as being occupied for 100% of these days.

$$P_{FTE} = P_{sitestaff} \times \frac{24}{6} \times 218$$

where:

$P_{sitestaff}$ = Number of staff accommodated on site.

4.2.5 Summary of FTE conversion factors

Table 3: Conversion factors for calculation of FTE per annum

	Morning	Afternoon	Evening
Normal School Operations			
Weekdays	147.0	49.0	49.0
Saturdays	20.0	10.0	15.0
Sundays	17.3	26.0	26.0
Hostel Accommodation			
School days	441.0		
Weekends	200.0		
Staff Accommodated on Site			
School days	441.0		
Other days	872.0		

4.3 Water demand of landscaped areas

Tondut (1976) and Stone (1978) both agree that the water demand of exterior landscaping accounts for a major portion of the total water use within facilities, such as schools.

During the data collection process for this project, an attempt was made to capture the overall extent of the landscaped areas within the sampled school by recording the number of grassed sports facilities, the extent of landscaped garden and the source of water used in the irrigation process.

4.3.1 Calculation of the areas of grassed sports fields

The following table of typical sport facility sizes is used in the calculation of sport field areas:

Table 4: Typical grassed area of sport code fields

Sport Code	Dimensions of playing area (m)	Dimensions of grassed area (m)	Total grassed area (m^2)
Athletics	130 x 80	130 x 80	10 400
Basketball	26 x 14	30 x 20	600
Netball	15 x 30	18 x 34	612
Hockey	100 x 60	104 x 64	6 656
Soccer / Rugby	Rugby: 100 x 75 Soccer: 100 x 50	110 x 80	8 800
Cricket	130 x 80	130 x 80	10 400
Tennis	11 x 24	15 x 30	450
Other (Baseball)	80 x 80	80 x 80	6 400

The total area of irrigated grassed sports fields is calculated as follows:

$$\sum(A_{Sport}) = n_{type} \times a_{type} \times p_{mains}$$

where:

A_{Sport} = Total area of irrigated grassed fields;

n_{type} = Number of particular sport code fields in the facility;

a_{type} = Area of sport code field from Table 4 above;

p_{mains} = Percentage of fields irrigated using mains supplied water.

4.3.2 Water demand of grassed sports fields

Rand Water (2003) advises that most warm season grasses, including Cynodon species and Kikuyu commonly found on school sports fields, be watered once a week during summer months, at a rate of 20 – 25 mm per week. This rate would be halved during the winter months. This water demand translates into the supplementary irrigation demand illustrated in Figure 8 below. This graph is based on calculations contained in the spreadsheet attached in Appendix D, using rainfall figures provided for daily rainfall during 1997 to 2001, by the Department of Transport. This calculation assumes that the rainfall measured during these years may be considered typical for the region.

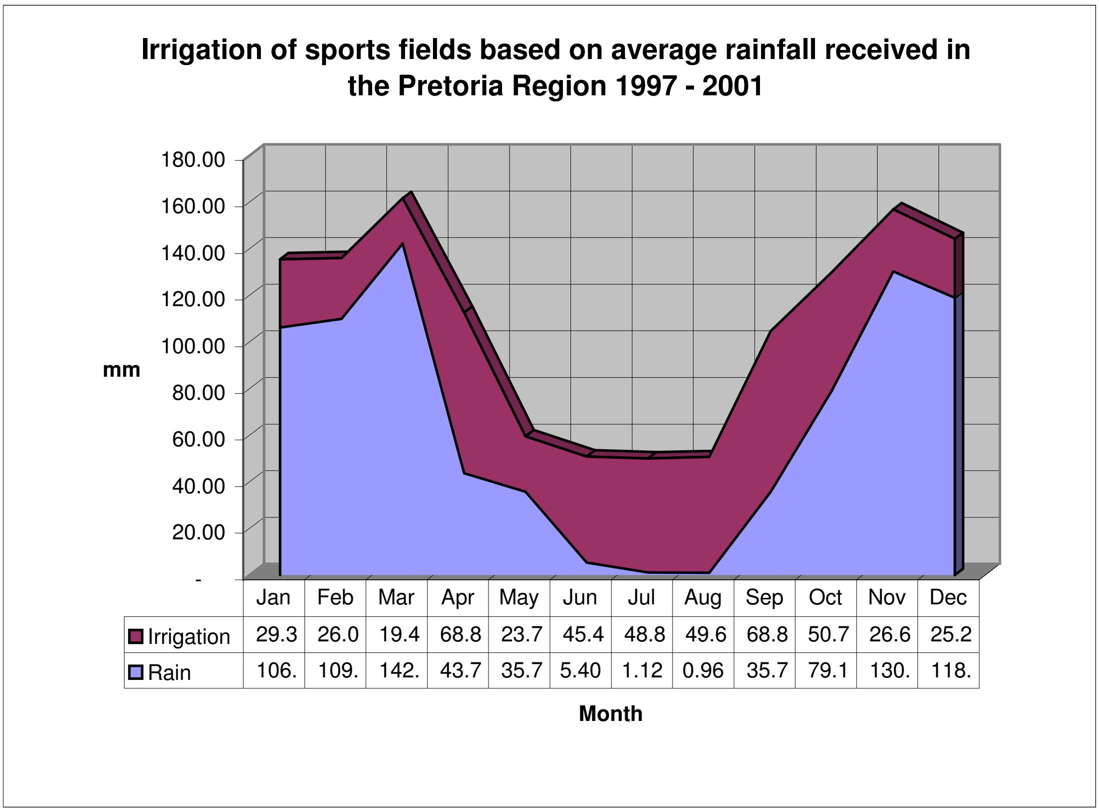


Figure 8: Supplementary irrigation to grassed sports fields

Table 5 provides the estimated annual water demand of grassed sports fields for the Pretoria region. This spreadsheet model was also used to derive supplementary irrigation requirements for the major South African cities, as listed in
Table 6.

Table 5: Supplementary irrigation required to grassed playing surfaces (litres / m^2): Pretoria Region

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
29	26	19	69	24	45	49	50	69	51	27	25	483

Table 6: Supplementary irrigation required for grassed playing surfaces (litres / m2): Major SA city regions

Region	Additional irrigation requirement (litres / m^2)	Region	Additional irrigation requirement (litres / m^2)	Region	Additional irrigation requirement (litres / m^2)
Bloemfontein	563	Kimberley	639	Port Elizabeth	559
Cape Town	684	Ladysmith	481	**Pretoria**	**483**
De Aar	730	Messina	694	Richards Bay	265
Durban	388	Mosselbaai	713	Saldhana	821
East London	458	Pietermaritzburg	406	Umtata	427
Johannesburg	445	Polokwane	618	Upington	808

The results of the audits of schools revealed that sports field and landscaping irrigation are carried out in the proportions reflected in Figure 9 below (Refer question 6c of the audit questionnaire). Relatively few of the respondent schools indicated that they did not irrigate sports fields and/or gardens, with a large proportion using boreholes to supplement irrigation of sports fields. Gardens and lawns were mostly irrigated from mains water supply.

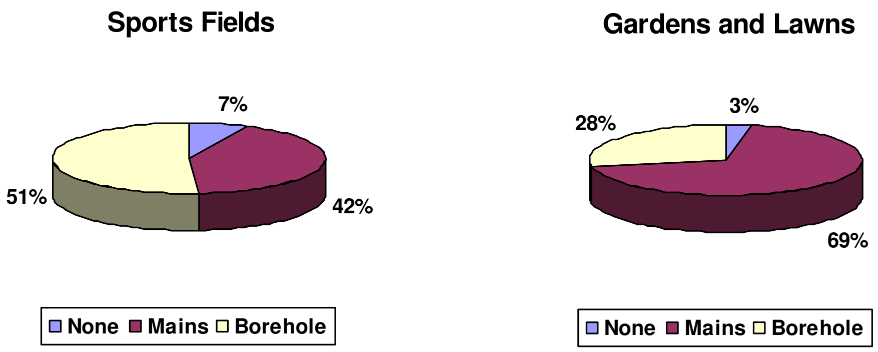


Figure 9: Proportional irrigation of grassed and planted landscaping

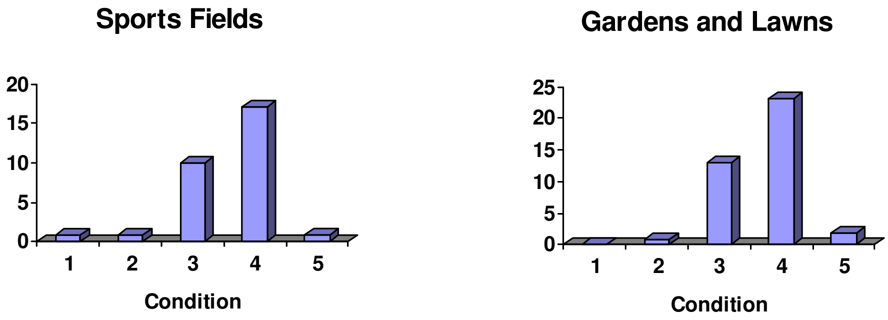


Figure 10: Observed condition of grassed and planted landscaping

Figure 10 summarises the observed condition of sports fields and planted gardens and lawns (Question 6d of the audit questionnaire). Noting that these observations were made during assessments on site during the spring months of October and November, and referring to the graph of rainfall in Figure 8, the generally "good" condition may be as a result of recent rains in the region.

Figure 11: Sports fields in good condition

Figure 12: Sports fields in poor condition

In order to adjust estimated water usage per square metre of grassed sports fields, in terms of the observed condition of these fields, the following arbitrary factors have been applied in the calculation of water demand:

Table 7: Multiplier for calculation of irrigation demand of grassed sports fields

6d. What is the overall condition of grassed sports surfaces?

Poor	1	2	3	4	5	Excellent
	Irrigation multiplier:					

The calculation of water demand of sports fields for a particular school is therefore:

$$V_{SportsFields} = A_{SportsFields} \times Y_{City} \times Multiplier \times P_{Mains}$$

where:

$V_{SportsFields}$ = Water demand of sports fields (litres per annum);

$A_{SportsFields}$ = Area of Sports Fields, calculated in 4.3.1 above;

Y_{City} = Supplementary irrigation required from

Table 6.

Multiplier is indicated in Table 7

P_{Mains} = Percentage of fields irrigated from mains supply, as indicated on (6b) of the survey instrument.

4.3.3 Calculation of the areas of landscaped gardens

The site measurement of landscaped gardens is a time consuming activity. Oliver (2001) presents physical data relating to the extent of landscaped gardens in a small sample of schools situated in Gauteng. These extents are given in Table 8 below:

Table 8: Measured extents of irrigated landscaped gardens at schools

School Name	School Type	Number of Learners and Staff	Irrigated Gardens (m2)	Irrigated gardens (m2 / person)
Arbor Primary School	Primary	1,049	-	-
Benoni High School	Secondary	1,735	320	0.18
Summerfields Primary	Primary	780	663	0.85
Farrarmere Primary	Primary	739	940	1.27
Laerskool Northmead	Primary	765	998	1.30
Tom Newby	Primary	1,224	1,801	1.47
Laerskool Louis Leipoldt	Primary	879	1,674	1.91
Laerskool Rooihuiskraal	Primary	1,356	2,598	1.92
Lyttelton Primary	Primary	787	1,711	2.18
Hoërskool Zwartkop	Secondary	1,762	3,854	2.19
Laerskool Valhalla	Primary	465	1,241	2.67
Laerskool Hennopspark	Primary	1,435	4,337	3.02
Hoërskool Eldoraigne	Secondary	1,573	6,948	4.42
Irene Primary School	Primary	910	4,106	4.51
Laerskool Uitsig	Primary	887	4,046	4.56
Laerskool Doringkloof	Primary	1,015	4,860	4.79
Laerskool Fleur	Primary	745	3,758	5.04
Lyttelton Manor HighSchool	Secondary	1,053	5,412	5.14
Sutherland High School	Secondary	1,291	6,643	5.15
Laerskool Swartkop	Primary	987	5,355	5.42
Laerskool Bakenkop	Primary	890	7,686	8.64

The following calculations have been based on the area of irrigated gardens contained in Table 8:

Table 9: Calculation of multipliers for area of irrigated gardens

Quintile	Maximum	Minimum	Average
1	1.73	0.00	0.86
2	3.46	1.73	2.59
3	5.18	3.46	4.32
4	6.91	5.18	6.05
5	8.64	6.91	7.77

The average area per person calculated in Table 9 has been used as the multipliers shown in Table 10, which have been applied to the populations of sampled schools, for the purpose of deriving an approximate extent of irrigated gardens, based on an assessment of extent on a 1 to 5 scale (Question 6g of the site audit instrument). The relationship between the assessment scale and the area multiplier in Table 10 is illustrated in Figure 13:

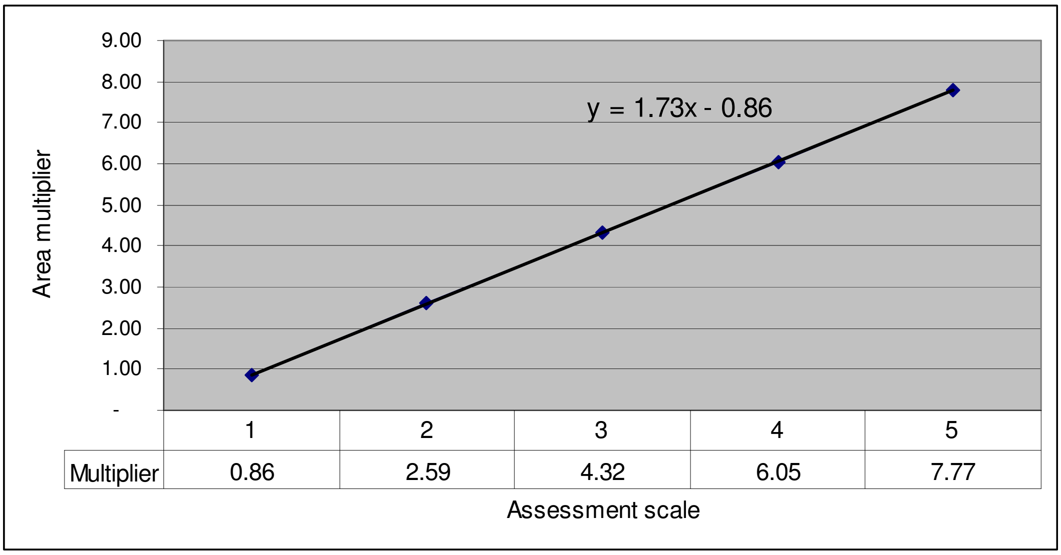


Figure 13: Linear relationship between extent of gardens scale and area multiplier

Figure 14: Irrigated lawns and gardens

Table 10: Multiplier for calculation of irrigated garden area

6g. What is the extent of planted gardens and lawns over the site?

Minimal	1	2	3	4	5	Extensive
	Population multiplier:					
	0.86	2.59	4.32	6.05	7.77	

The extent of gardens is calculated as follows:

$$A_{Gardens} = (n_{Learners} + n_{Staff}) \times PopulationMultiplier$$

Where:

$n_{Learners}$ = Number of learners enrolled at the school;

n_{Staff} = Number of staff members at the school;

PopulationMultiplier is listed in Table 10 above.

Table 11: Multiplier for calculation of irrigation demand of planted gardens and lawns (See also Table 7)

6k.✍What is the overall condition of planted gardens and lawns?

Poor	1	2	3	4	5	Excellent
	Irrigation multiplier:					

The calculation of water demand of sports fields for a particular school is therefore:

$$V_{Gardens} = A_{Gardens} \times Y_{City} \times IrrigationMultiplier \times P_{Mains}$$

where:

$V_{Gardens}$ = Water demand of landscaped gardens (litres per annum);

$A_{Gardens}$ = Area of gardens, calculated above;

Y_{City} = Supplementary irrigation required from Table 6.

IrrigationMultiplier is indicated in Table 11 above.

P_{Mains} = Percentage of gardens irrigated from mains supply, as indicated on (6h) of the survey instrument.

4.4 Overview of the sampled schools

Table 12 provides a summary of the characteristics of the sampled schools, from data collected, showing overall totals of various aspects of these facilities. Detailed performance criteria per school will be described later in this section.

Table 12: Overview of sample schools

Description / Aspect	School Type			
	Total	Primary	Combined	Secondary
Number of schools sampled	64	40	4	20
Total number of learners	56,250	32,519	3,117	20,614
Total number of staff	2,574	1,360	209	1,005
Total FTE population	9,755,206	5,395,329	658,917	3,700,960
Total FTE: School hours	8,647,128	4,980,213	488,922	3,177,993
Total FTE: Weekdays after school hours usage	391,853	193,893	43,855	154,105
Total FTE: Weekend usage	204,647	120,122	18,160	66,365
Total FTE: Accommodation on site (Hostels and Staff)	511,578	101,101	107,980	302,497
Number of schools with grassed sports fields	37	24	2	11
Estimated extent of grassed sports fields (m^2)	854,052	404,868	36,424	412,760
Number of schools with landscaped gardens	64	40	4	20
Estimated extent of landscaped gardens (m^2)	240,000	133,300	10,300	96,400
Estimated extent of mains irrigated grassed sports fields (m^2)	332,334	190,884	-	141,450
Estimated extent of mains irrigated landscaped gardens (m^2)	191,900	110,800	2,400	78,700
Number of Schools with boreholes	22	13	2	7
Estimated extent of borehole irrigated grassed sports fields (m^2)	477,506	178,172	36,424	262,910
Estimated extent of borehole irrigated landscaped gardens (m^2)	44,500	21,900	7,900	14,700

4.5 Calculating water use per FTE

The water consumption, for those schools for which accounts were collected, is tabulated in Table 13 below, based on the total annual metered and billed water consumption, divided by the total full time equivalent (FTE) population. The consumption per FTE has been rounded to the nearest 10 litres per FTE in the rightmost column. These consumption figures are illustrated graphically in Figure 15 below:

Table 13: Metered water consumption for schools which submitted utility accounts

EMIS Number	School Name	Full Time Equivalent Population (per annum)	Water Consumption (kilolitres per annum)	Usage Per FTE Overall: (Litres per FTE)	Rounded Usage : (Litres per FTE)
231373	RIETONDALE PRIMARY	157,469	133	1	**-**[1]
260018	ASTON MANOR PRIMARY	153,876	1,004	7	**10**[1]
250092	CONSTANTIA KLOOF PRIMARY	149,371	2,710	18	**20**
261206	SHUKUMANI PRIMARY	127,929	2,466	19	**20**
250688	LAERSKOOL GUSTAV PRELLER	76,959	1,642	21	**20**
251025	SILVERFIELDS PRIMARY	101,127	2,118	21	**20**
231605	DAVID HELLEN PETA SECONDARY	156,310	3,628	23	**20**
260422	LAERSKOOL NOBEL PRIMARY	113,908	2,613	23	**20**
220624	EZAZI PRIMARY	62,034	1,572	25	**30**
260109	HOëRSKOOL BIRCHLEIGH	125,766	3,291	26	**30**
241141	REDIBONE PRIMARY	66,738	2,008	30	**30**
211235	WILLOWRIDGE HIGH	179,407	5,560	31	**30**
250639	LAERSKOOL DR HAVINGA	242,842	8,216	34	**30**
250118	DISCOVERY PRIMARY	179,250	6,197	35	**40**
261123	MVELAPHANDA PRIMARY	128,840	4,477	35	**40**
220707	JAFTA MAHLANGU SECONDARY	164,463	5,987	36	**40**
250241	HOëRSKOOL JAN DE KLERK	114,200	4,192	37	**40**
231936	MAREMATLOU PRIMARY	60,775	2,252	37	**40**
260810	SPARTAN HIGH	46,015	1,785	39	**40**
241497	UBUHLE-BEZWE JUNIOR SECONDARY	134,954	5,317	39	**40**
250266	HOëRSKOOL NOORDHEUWEL	231,009	9,233	40	**40**
260091	EDLEEN PRIMARY	150,871	6,308	42	**40**
220368	LAERSKOOL RIETFONTEIN-NOORD	88,754	3,899	44	**40**
261685	SHANGRI-LA ACADEMY	90,850	4,330	48	**50**
220178	HOëRSKOOL OOS-MOOT	214,175	10,546	49	**50**
250662	LAERSKOOL FLORIDA	126,596	6,282	50	**50**
250969	PRINCESS PRIMARY	159,132	8,794	55	**60**
220863	MOGALE PRIMARY	150,744	8,926	59	**60**
210641	LAERSKOOL BAKENKOP	136,476	8,259	61	**60**
241109	DIMAKATSO PRIMARY	144,946	9,027	62	**60**
250720	LAERSKOOL HORISON	151,313	9,450	62	**60**
211086	ST MARY'S DIOCESAN FOR GIRLS	243,129	15,750	65	**70**
250860	MONUMENT PRIMARY	172,278	11,783	68	**70**
260430	LAERSKOOL VAN RIEBEECKPARK	187,662	12,928	69	**70**
231670	FLAVIUS MAREKA SECONDARY	166,102	12,182	73	**70**
241166	RODNEY MOKOENA PREPARATORY	252,743	19,056	75	**80**
240804	KHENSANI PRIMARY	86,615	7,405	85	**90**
230813	LAERSKOOL DANVILLE	78,128	6,628	85	**90**
231910	MAKGWARANENG PRIMARY	141,893	17,597	124	**120**[2]
230185	BURGHER RIGHT PRIMARY	183,736	23,279	127	**130**[2]
220194	H/S STAATSPRESIDENT C R SWART	107,996	14,745	137	**140**[2]
210906	LYTTELTON MANOR HIGH	161,600	24,051	149	**150**[2]
210187	HOëRSKOOL GARSFONTEIN	227,319	48,863	215	**220**[2]
220343	LAERSKOOL NELLIE SWART	44,228	12,308	278	**280**[2]
	Mode				**40**

Note 1: Exceptionally low water consumption may indicate meter out of order, or not read by service provider

Note 2: Exceptionally high water consumption may indicate extensive wastage, leakage and / or possible losses such as theft.

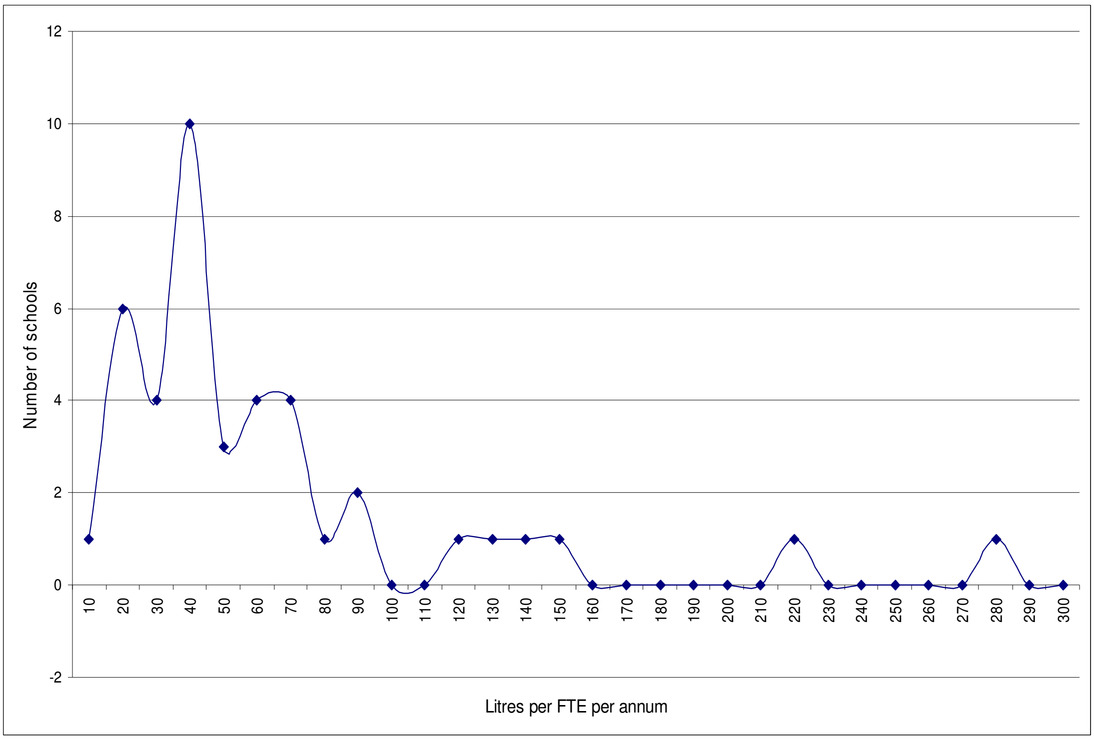


Figure 15: Distribution of total water consumption per FTE per annum

Figure 15 clearly demonstrates the positively skewed distribution of consumption data, around the mode of 40 litres per FTE. It should be noted that the *mode* has been used as the most appropriate descriptor of data tendency, given that the data presented in Figure 15 represents a skewed sample, best described by the *mode*. At the broadest level of key performance indicator, this value may be considered to represent an indicative consumption per FTE for schools.

It should be noted that a number of confounding factors may adversely affect the accuracy of this value. These factors include:

- Inaccuracy of metering and metering data capture;
- Provisional meter readings. Wherever possible, these provisional readings have been filtered out during the data cleaning process. However, there may be instances where the occurrence of a provisional reading was not apparent, and was not treated as such;
- Landscape watering;
- Double counting of hostel occupants, as described in 4.2.3.

Table 14: Estimated occupant water consumption + losses (litres per FTE) for schools which submitted utility accounts

Name	Total Consumption	Estimated Irrigation Consumption	Estimated Occupant Consumption and Losses	Estimated Occupant Consumption and Losses per FTE
REDIBONE PRIMARY	2,008,000	1,854,720	153,280	-
LAERSKOOL FLORIDA	6,282,000	5,566,672	715,328	5
PRINCESS PRIMARY	8,794,000	7,773,595	1,020,405	5
SILVERFIELDS PRIMARY	2,118,000	1,043,280	1,074,720	10
SHUKUMANI PRIMARY	2,466,000	1,062,600	1,403,400	10
LAERSKOOL NOBEL PRIMARY	2,613,000	956,340	1,656,660	15
DAVID HELLEN PETA SECONDARY	3,628,000	1,333,080	2,294,920	15
EZAZI PRIMARY	1,572,000	521,640	1,050,360	15
LAERSKOOL GUSTAV PRELLER	1,642,000	212,520	1,429,480	20
EDLEEN PRIMARY	6,308,000	2,871,338	3,436,662	25
KHENSANI PRIMARY	7,405,000	5,409,600	1,995,400	25
LAERSKOOL VAN RIEBEECKPARK	12,928,000	8,578,080	4,349,920	25
DISCOVERY PRIMARY	6,197,000	1,816,080	4,380,920	25
JAFTA MAHLANGU SECONDARY	5,987,000	1,816,080	4,170,920	25
MVELAPHANDA PRIMARY	4,477,000	772,800	3,704,200	30
MAREMATLOU PRIMARY	2,252,000	386,400	1,865,600	30
LAERSKOOL DR HAVINGA	8,216,000	618,240	7,597,760	30
SPARTAN HIGH	1,785,000	309,120	1,475,880	30
HOëRSKOOL JAN DE KLERK	4,192,000	260,820	3,931,180	35
HOëRSKOOL NOORDHEUWEL	9,233,000	231,840	9,001,160	40
UBUHLE-BEZWE JUNIOR SECONDARY	5,317,000	-	5,317,000	40
LAERSKOOL RIETFONTEIN-NOORD	3,899,000	-	3,899,000	45
SHANGRI-LA ACADEMY	4,330,000	-	4,330,000	50
HOëRSKOOL OOS-MOOT	10,546,000	-	10,546,000	50
MOGALE PRIMARY	8,926,000	1,246,140	7,679,860	50
RODNEY MOKOENA PREPARATORY	19,056,000	5,873,280	13,182,720	50
DIMAKATSO PRIMARY	9,027,000	850,080	8,176,920	55
LAERSKOOL HORISON	9,450,000	193,200	9,256,800	60
ST MARY'S DIOCESAN FOR GIRLS	15,750,000	676,200	15,073,800	60
MONUMENT PRIMARY	11,783,000	193,200	11,589,800	65
FLAVIUS MAREKA SECONDARY	12,182,000	840,420	11,341,580	70
LAERSKOOL DANVILLE	6,628,000	579,600	6,048,400	75
LYTTELTON MANOR HIGH	24,051,000	11,024,765	13,026,235	80
HOëRSKOOL STAATSPRESIDENT C R SWART	14,745,000	5,583,480	9,161,520	85
MAKGWARANENG PRIMARY	17,597,000	695,520	16,901,480	120
BURGHER RIGHT PRIMARY	23,279,000	927,360	22,351,640	120
HOëRSKOOL GARSFONTEIN	48,863,000	11,806,838	37,056,162	165
LAERSKOOL NELLIE SWART	12,308,000	3,187,220	9,120,780	205
The following schools' calculations returned negative consumption figures after deducting estimated irrigation consumption:				
RIETONDALE PRIMARY				
CONSTANTIA KLOOF PRIMARY				
WILLOWRIDGE HIGH				
LAERSKOOL BAKENKOP				
ASTON MANOR PRIMARY				
HOëRSKOOL BIRCHLEIGH				
Mean				49
Median				38
Standard Deviation				44
Mode				**25**

Table 14 represents the water consumption per FTE, resulting from deducting landscape and sports field irrigation estimates from total metered consumption. This irrigation consumption has been calculated by applying the algorithms derived in 4.3.2 and 4.3.3 above. The resultant consumption per FTE will also include losses from leaks, vandalism and theft. These results are again reflected in Figure 16 below, showing the positively skewed distribution of consumption. The value of the mode for derived consumption is 25 litres per FTE.

This derived consumption correlates reasonably with the Canadian Day Schools investigation (Robson 1966), where an annual consumption of 10 to 33 litres per day, averaging 21 litres, which confirms the estimated consumption per FTE in Hypothesis 1.

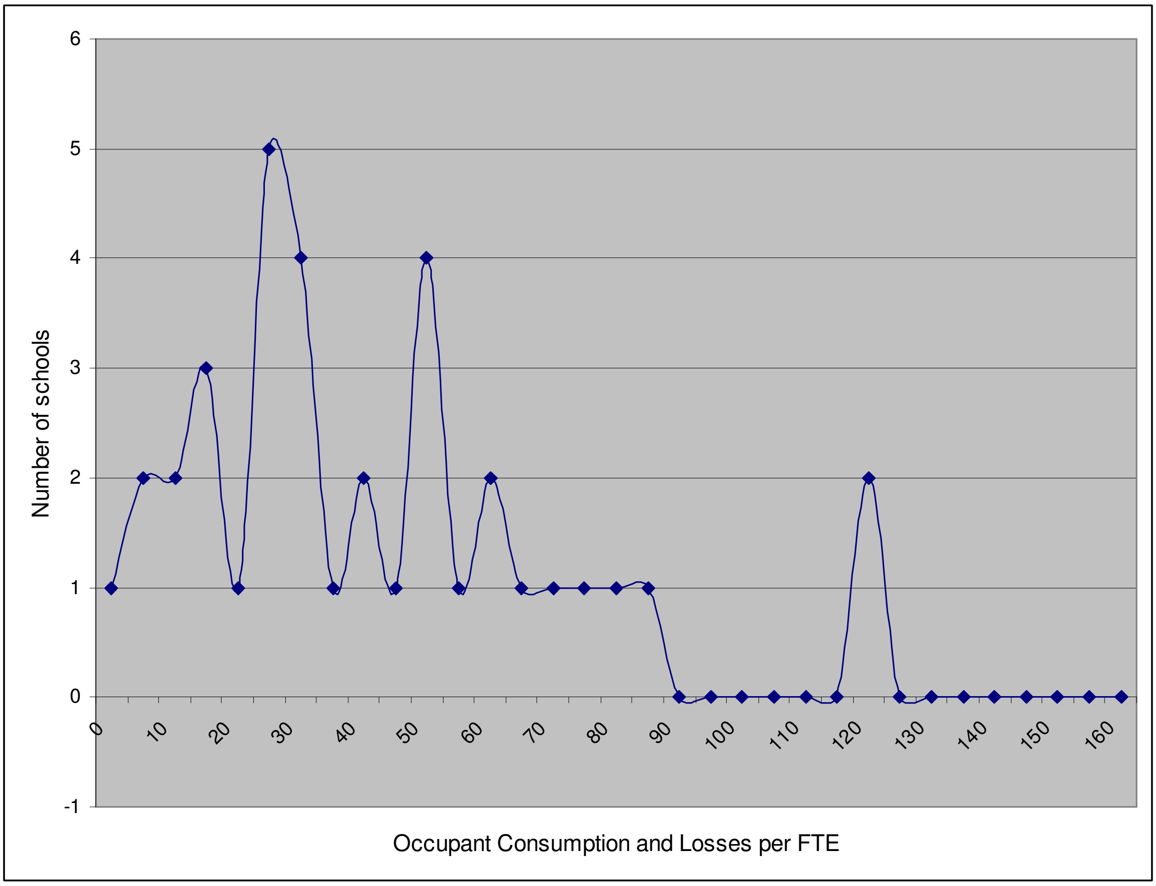


Figure 16: Distribution of occupant consumption per FTE per annum (after deduction of landscape use)

4.6 Simulating projected water use

In order to effectively manage water consumption, at the broadest level, school managers need to estimate a realistic anticipated consumption per annum, for their schools.

The following section will construct and test such a water consumption model for schools.

4.6.1 Simulated occupant consumption

Table 15 comprises a matrix of site population, describing the facility loading within various aspects of the site, during various times of the school week as follows:

In Section A, the population of the school is estimated, or measured, during the various utilisation periods of a typical week. These population estimates are tabulated in this section to be multiplied by a conversion factor, to derive a total "Full time equivalent" (FTE) population for the school;

Sections B and C require the population of permanent and hostel accommodation;

Section D gathers information required for the calculation of estimated water demands for external landscaped areas, including sports fields and gardens.

Table 15: Simulation input table

SECTION A: Population loading of the school premises:

This is the number of persons on the school premises during each period, including platoon school, double sessions, community or commercial use of the school or grounds. Hostel boarders and staff accommodated on site should only be included during school hours.

Day	Number of persons on school premises:		
	School Day	Afternoon	Evening
Weekdays	P_1	P_2	P_3
Saturdays	P_4	P_5	P_6
Sundays	P_7	P_8	P_9

SECTION B: Hostel Accommodation:

Hostel beds occupied	P_{10}
Percentage of boarders in hostel over weekends	W %

SECTION C: Staff Accommodation:

This is the number of staff permanently accommodated on site, including family members.

Number of Staff accommodated on site	P_{11}

Calculating simulated occupant water consumption ($V_{Occupant}$) is achieved by applying the following algorithm to the data collected in Sections A, B and C above:

$$V_{Occupant} = 25 \times \begin{bmatrix} 147P_1 + 49P_2 + 49P_3 + 20P_4 + 10P_5 + 15P_6 + 17.3P_7 \\ + 26P_8 + 26P_9 + 441P_{10} + 200WP_{10} + 1313P_{11} \end{bmatrix}$$

4.6.2 Simulated irrigation consumption

SECTION D: Irrigated Sports Fields on the school premises:

This is the number of grassed sports fields on the premises which are irrigated using mains water supply. Where a field is used for multiple purposes (e.g.: Athletics and rugby) this field should be counted once only.

Sport type	Number of irrigated grassed fields
Athletics	N_1
Basketball	N_2
Netball	N_3
Hockey	N_4
Rugby / Soccer	N_5
Cricket	N_6
Tennis	N_7
Baseball	N_8

Condition of irrigated grassed sports fields (C_1)				
Poor		Fair		Excellent
1	2	3	4	5
Extent of mains irrigated planted gardens and lawns (A_1)				
Small Area				Extensive Area
1	2	3	4	5
Condition of irrigated planted gardens and lawns (C_2)				
Poor		Fair		Excellent
1	2	3	4	5
Percentage of irrigated planted gardens and lawns which are irrigated using mains supply				**M%**
Supplementary irrigation requirement (from Table 6)				**Y**

According to the results of site audits, the majority of schools irrigating sports fields and landscaped gardens make use of moveable overhead sprinkler systems. Rand Water (2003) lists the efficiency of such moveable sprinkler systems as 75%. The remaining 25% of water passing through the sprinkler nozzles is lost to windblown spray or evaporation.

4.6.3 Total simulated water consumption

Total simulated water consumption, in litres per annum, would therefore be:

$$\boxed{V_{Total} = V_{Occupant} + V_{Irrigation}}$$

Calculating simulated irrigation consumption ($V_{Irrigation}$):

$$V_{SportFields} = Y \times \begin{bmatrix} 10400N_1 + 600N_2 + 612N_3 + 6656N_4 + 8800N_5 + \\ 10400N_6 + 450N_7 + 6400N_8 \end{bmatrix} \times \frac{C_1}{5} \times \frac{1}{0.75}$$

$$V_{Gardens} = Y \times [(1.73A_1 - 0.86)P_1] \times \frac{C_2}{5} \times M\,\% \times \frac{1}{0.75}$$

$$\boxed{V_{Irrigation} = V_{SportsFields} + V_{Gardens}}$$

4.6.4 Testing the model

Table 16 shows the results of applying the model developed above, to those schools for which actual metered water consumption figures are available. The supplementary irrigation demand for Pretoria region was used in these calculations.

Table 16: Simulation of water consumption using the model (Kilolitres / annum)

	A	B	C	D	E	F	G	H	J
Name	$V_{Occupants}$	$V_{Irrigation}$	V_{Total}	V_{Actual}	Var.	Losses	Under metering	Efficient fittings	Leaking fittings
TOTALS	**155,192**	**223,328**	**378,520**	**378,797**		**128,310**	**128,452**		
Burgher Right PS	4,593	2,036	6,629	23,279	251%	16,650	-	0%	7%
Makgwaraneng PS	3,547	1,567	5,114	17,597	244%	12,483	-	2%	7%
Monument PS	4,307	342	4,649	11,783	153%	7,134	-	81%	5%
LS Horison	3,783	354	4,137	9,450	128%	5,313	-	8%	16%
LS Nellie Swart	1,018	4,379	5,397	12,308	128%	6,911	-	3%	7%
LS Danville	1,946	1,052	2,998	6,628	121%	3,630	-	21%	4%
St Mary's Diocesan	6,075	1,102	7,177	15,750	119%	8,573	-	0%	1%
HS Garsfontein	5,462	16,861	22,323	48,863	119%	26,540	-	2%	3%
Flavius Mareka SS	4,153	1,850	6,003	12,182	103%	6,179	-	2%	4%
HS Oos-Moot	5,347	-	5,347	10,546	97%	5,199	-	11%	4%
Shangri-La Academy	2,279	-	2,279	4,330	90%	2,051	-	26%	2%
Dimakatso PS	3,624	1,133	4,757	9,027	90%	4,270	-	5%	7%
LS Rietfontein-Noord	2,215	-	2,215	3,899	76%	1,684	-	4%	5%
Ubuhle-Bezwe Junior SS	3,179	-	3,179	5,317	67%	2,138	-	4%	2%
HS Noordheuwel	5,775	421	6,196	9,233	49%	3,037	-	9%	3%
Mogale PS	3,769	2,321	6,090	8,926	47%	2,836	-	6%	0%
HS St C R Swart	2,700	7,540	10,240	14,745	44%	4,505	-	0%	15%
Lyttelton Manor HS	4,066	15,140	19,206	24,051	25%	4,845	-	4%	14%
Rodney Mokoena Prep	6,319	9,147	15,466	19,056	23%	3,590	-	54%	14%
HS Jan De Klerk	2,855	595	3,450	4,192	22%	742	-	0%	8%
LS Dr Havinga	6,071	1,074	7,145	8,216	15%	-	-	50%	4%
Spartan HS	1,150	679	1,829	1,785	-2%	-	-	14%	7%
Marematlou PS	1,519	848	2,367	2,252	-5%	-	-	0%	4%
Mvelaphanda PS	3,221	1,749	4,970	4,477	-10%	-	-	3%	3%
Jafta Mahlangu SS	4,112	3,404	7,516	5,987	-20%	-	1,529	8%	1%
Discovery PS	4,481	3,385	7,866	6,197	-21%	-	1,669	0%	4%
Edleen PS	3,625	4,392	8,017	6,308	-21%	-	1,709	0%	6%
LS Van Riebeeckpark	4,692	12,369	17,061	12,928	-24%	-	4,133	4%	7%
Khensani PS	2,165	7,841	10,006	7,405	-26%	-	2,601	0%	0%
LS Gustav Preller	1,924	490	2,414	1,642	-32%	-	772	0%	3%
Ezazi PS	1,551	987	2,538	1,572	-38%	-	966	0%	0%
Princess PS	3,978	11,274	15,252	8,794	-42%	-	6,458	11%	7%
LS Florida	3,165	7,777	10,942	6,282	-43%	-	4,660	51%	5%
David Hellen Peta SS	3,908	2,478	6,386	3,628	-43%	-	2,758	0%	15%
LS Nobel PS	2,851	1,765	4,616	2,613	-43%	-	2,003	13%	6%
Silverfields PS	2,528	1,979	4,507	2,118	-53%	-	2,389	34%	5%
Shukumani PS	3,198	2,387	5,585	2,466	-56%	-	3,119	10%	12%
Redibone PS	1,735	2,897	4,632	2,008	-57%	-	2,624	3%	9%
Willowridge HS	4,224	11,611	15,835	5,560	-65%	-	10,275	0%	5%
LS Bakenkop	3,412	20,286	23,698	8,259	-65%	-	15,439	13%	3%
Constantia Kloof PS	3,742	7,059	10,801	2,710	-75%	-	8,091	5%	6%
HS Birchleigh	3,144	30,008	33,152	3,291	-90%	-	29,861	5%	3%
Aston Manor PS	3,847	17,653	21,500	1,004	-95%	-	20,496	32%	2%
Rietondale PS	3,937	3,096	7,033	133	-98%	-	6,900	10%	2%

In summary, therefore:

Description of water use	Kilolitres
Metered water uses, reflected by the actual utility accounts submitted by schools, are listed in column "A" of Table 16:	378,797
Under-metered water usage is calculated as the difference between column "C" and column "D" where C>D. From Table 16 this under-metering is totaled under column "G":	128,452
Estimated total water consumption:	507,249 (34% of "A")
Estimated losses are calculated as the difference between column "C" and column "D" where C<D. From Table 16 these losses are totaled under column "F":	128,310 (25% of estimated total water consumption)
Estimated water consumed by school processes (excluding losses):	378,939
Total FTE per annum population of schools which submitted accounts:	6,240,528
Estimated consumption per FTE per annum	61 litres

Table 16 highlights a number of important issues:

- Variances from simulated consumption, in excess of 20% either way, are highlighted with a light red background;
- Serious estimated apparent losses of water, for which the schools are being billed, amounting to a total of 128 310 kilolitres per annum, a component of roughly 25% of the total actual water use for the tabulated schools, valued at about R797 000 per annum
- Serious metering failures at a number of schools, leaving these School Governing Bodies legally liable to the supply authorities for three years retrospective under-billed water use. The estimated value of unbilled water to the local authority is R798 000, approximately 34% over and above the actual water consumed by the listed schools. The legal exposure of these School Governing Bodies amounts to a cumulative R2,394M;
- Hypothesis 3 estimated water losses at 30% of total water use. The average estimated losses, from the model, due to leakages and under-metering is 29,5% thereby closely confirming this hypothesis.
- The projections shown disregard the technology installed in the school. Schools with water-efficient fittings installed are highlighted in column "H". There does not appear to be any clear correlation between the incidence of water efficient devices, and reduction in

overall water use. It is suggested that this is due to the dilution of ablution consumption by irrigation consumption;

- The highest incidence of leaking fittings appears to occur within schools where variance from simulation is above 25% (Refer column "J").

The correlation between actual and modelled water use, for this group of schools, is illustrated in Figure 17. The linear trend line derived from this data suggests that there is a 25% excess in actual water use, against projected. This deviation, however, may be reduced should a significantly larger sample of schools data be analysed in such a table.

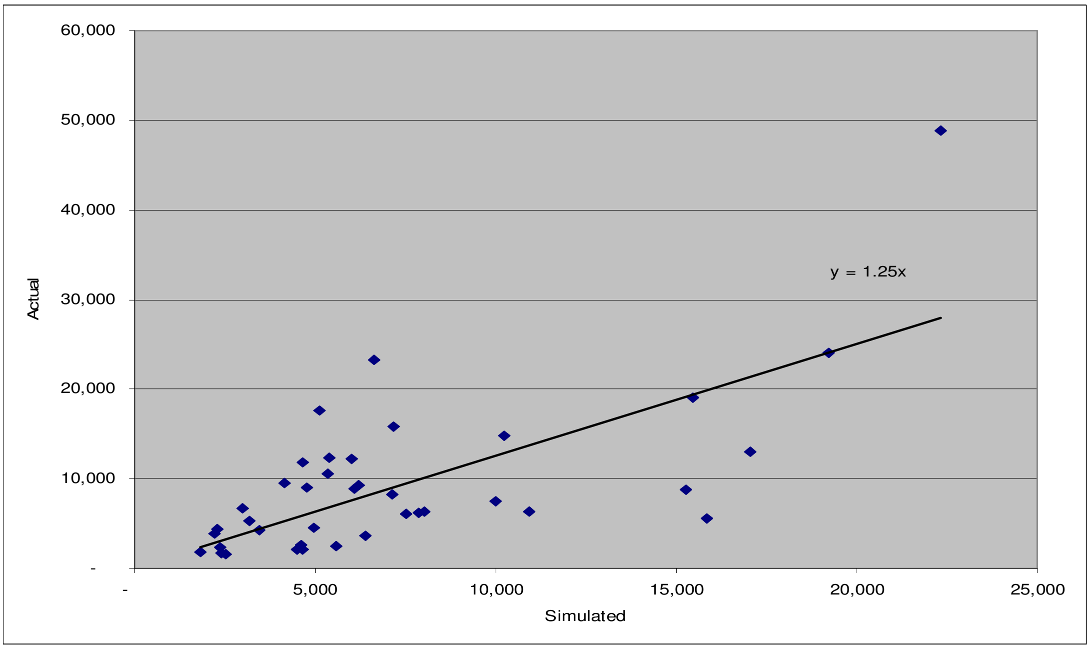


Figure 17: Correlation between actual and simulated consumption

Total water use, including estimated mains supply and borehole, adjusted pro-rata for under-metering in each category, is illustrated in Figure 18 below:

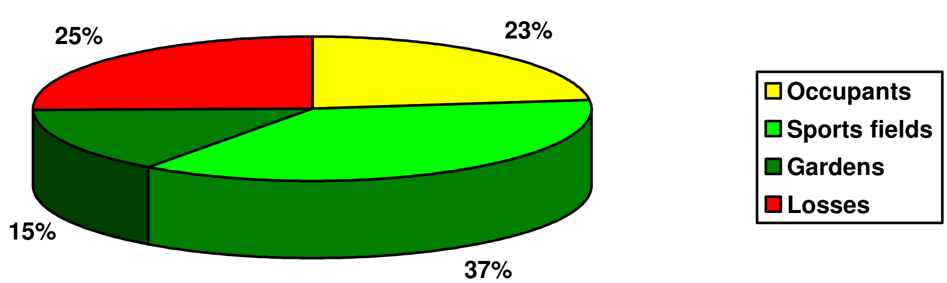


Figure 18: Proportional water use in schools (based on total simulated use for all sample schools)

The proportions of use illustrated do not support Hypothesis 2 that water usage for the irrigation of landscaped gardens and sports fields will account for 63 litres per FTE. Based on the total estimated consumption of 61 litres per FTE per annum (See summary of Table 16), and applying the percentage derived in Figure 18, irrigation accounts for only 32 lites per FTE. This may result from the large influence of previously disadvantaged schools, or “township schools”, where the incidence and extent of sports fields and landscaped gardens is minimal. Figure 18 again confirms Hypothesis 3, that approximately 30% of water use is due to losses.

In terms of the relative performance of primary schools, compared against secondary schools, Figure 19 illustrates and lists central tendency of water consumption per FTE. The large difference in average consumption may be largely due to the difference in areas of sports fields per learner at secondary schools, as illustrated in Figure 20. Figure 20 was calculated using the model for areas of sports fields and landscaped gardens and lawns constructed in 4.6.2 on page 56. This confirms the Hypothesis 3 statement that secondary schools consume more water than primary schools per FTE.

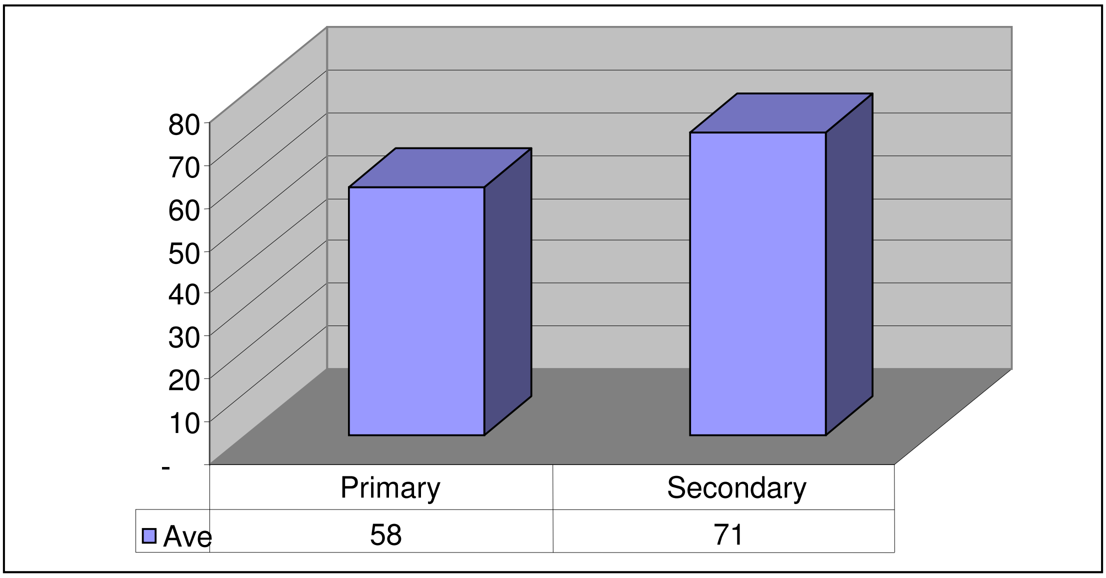
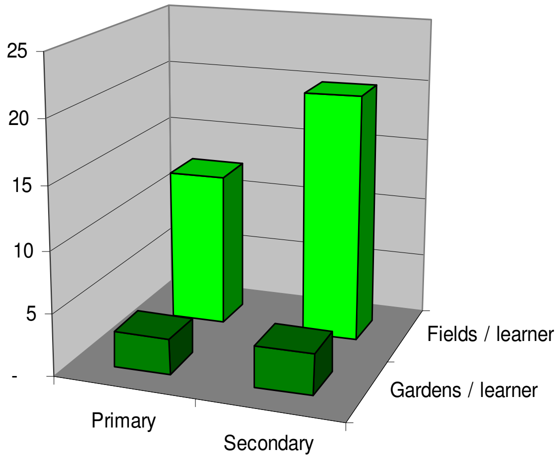


Figure 19: Comparative total water use (litres per FTE): primary vs. secondary schools

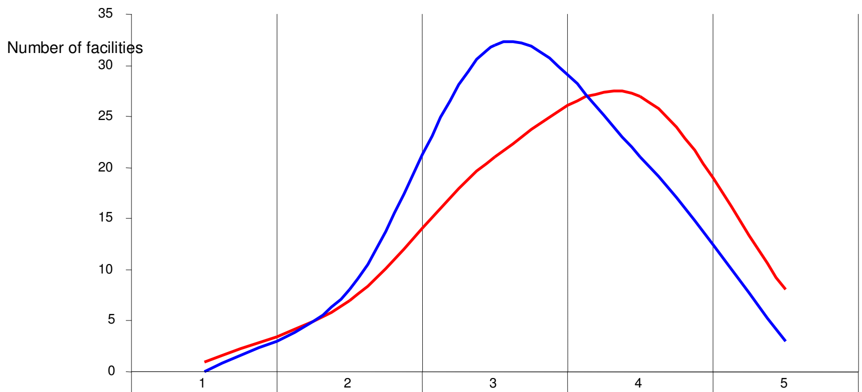


	Primary	Secondary
Gardens / learner	3	3
Fields / learner	12	20

Figure 20: Comparative areas (m^2) of sports fields and gardens at Primary and Secondary schools

4.7 Observed facility condition

During site visits to the sample schools, auditors made an assessment of the condition of the school facility "as a whole". The distribution of these assessments is illustrated in Figure 21 where condition "1" is "poor condition" and condition "5" is "excellent condition". Similar assessments were carried out by school principals, during the national SRN2 audit in 2000. (South Africa: Department of Education, 2000). The principals' assessments are overlaid over the assessments carried out during this project, in Figure 21. The distribution of the SRN2 assessments represents a more favourable normal distribution of condition assessment, against a negatively skewed project assessment.



	1	2	3	4	5
Audit	1	7	21	27	8
SRN	0	8	32	21	3

Building condition

Figure 21: Distribution of assessments of facility condition (compared to SRN2)

Facility condition assessment is a widely debated topic, dependant entirely upon the subjective assessment of state of facility repair, by the auditor. Auditors carrying out site visits for this project visited site for extremely short periods of time (approximately one hour per school), during which time they inspected facility ablutions and external planted and landscaped areas. Auditors may not have formulated a well informed assessment of facility condition, resulting in a tendency to rate condition higher, rather than lower. Future site audits, where facility condition assessments are included, should provide a more rigorous assessment process, to provide more accurate data.

Table 17: Consumption per FTE by facility condition

Facility Condition	Poor 1	2	3	4	Excellent 5
Average consumption (litres per FTE)	0	37	76	52	15
Number of schools	0	3	21	13	2

Table 17 above lists average billed water consumption per FTE, grouped by facility condition, for those schools from which accounts were received. Given the previous discussions relating to classification of facility condition, the SRN2 condition indicator has been used in this table. Whilst the average consumption does reduce from a condition 3 facility (minor repairs required) to a condition 5 facility (new or refurbished condition), the numbers of schools falling into category 2 and category 5 do not provide a sufficient sample size to allow reliable conclusions to be drawn.

4.8 Water component failure

Observed incidence of leakage and failure of water installation components is illustrated in Figure 22. Data has been presented against facility condition as assessed during the SRN2 survey, indicating an increasing incidence of failure in deteriorating facility conditions. Notably, the incidence of component failure remains significantly high, even in well maintained facilities in good condition. Water installation components installed in school ablutions are subjected to extreme demands on their performance, due to the high frequency of use and high incidences of vandalism, as noted also by Mackenzie (2000).

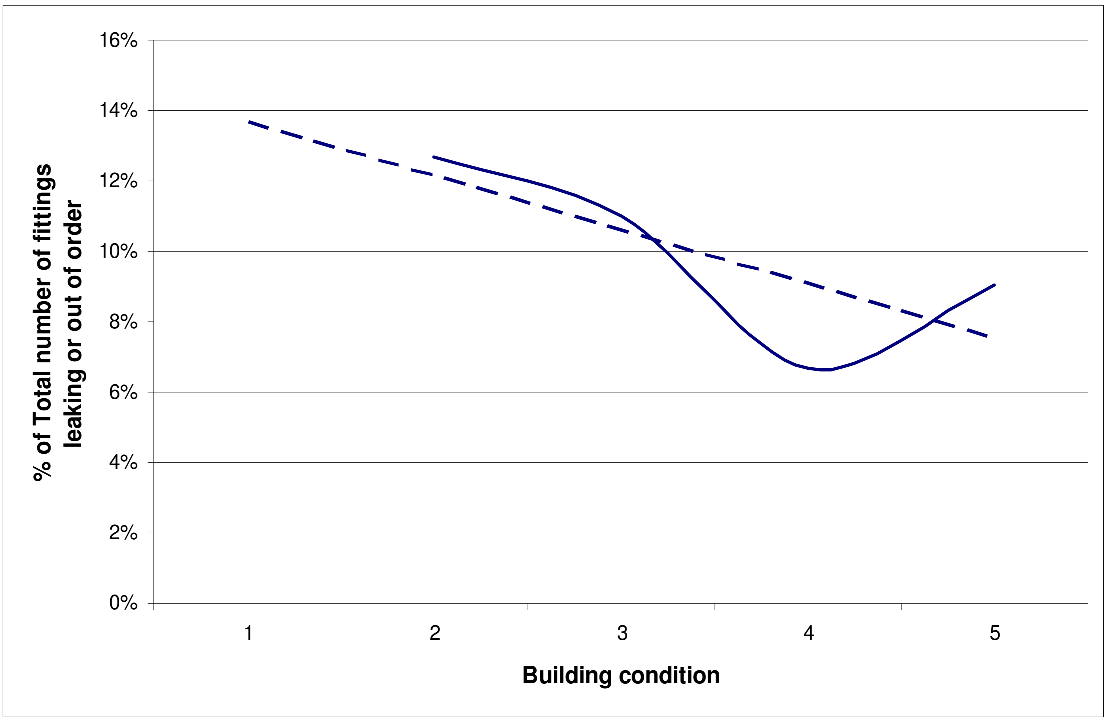


Figure 22: Incidence of water installation components leaking or out of order

Table 18 summarizes the installation components observed during site visits, noting the relationship between various types of technology and component failure. The high incidence of failure of demand taps on wash basins is attributable to a single school, Laerskool Florida, where the school has retrofitted demand taps, replacing bib taps. Unfortunately the quality of installed components was not high, resulting in the early failure of 35% of these fittings within the first year of operation.

Damage to urinal

Unserviceable basin tap

Urinal continuously running

Drainage plumbing makes cleaning difficult

Figure 23: Maintenance observations during audits

Table 18: Summary of observations of water installation fittings

	Wash Basin Taps		WC Suites			Urinals				Other		
	Bib tap	Demand tap	Single flush WC	Dual flush WC	Push button WC	Tilt tray Urinal	Push button Urinal	Push button Bowl	Auto flush bowl	Shower	Sink	Slop hopper
Total number of fittings observed	1376	154	1488	26	244	98	39	75	8	42	49	0
Alternative technologies installed within groups	90%	10%	85%	1%	14%	45%	18%	34%	4%			
Fittings leaking	5%	1%	6%	4%	3%	17%	3%	5%	13%	0%	0%	n/a
Fittings out of order	5%	8%	4%	4%	1%	4%	5%	8%	0%	0%	0%	n/a
Taps left running	2%									0%	0%	n/a

Also highlighted on Table 18 is the high frequency of leakage in automatically flushing urinals. The table highlights the improvement in performance of urinals in the case of demand valve flushing mechanisms, in place of tilt trays and automatic cisterns. Typically, where these fittings are found, by caretakers, to be leaking profusely, they tend to be shut off, giving rise to unsanitary conditions in the boys' ablutions. Although the performance of tilt tray automatically flushing urinals is found to be undesirable, there remains a high incidence of these fittings in school ablutions (Table 18 indicated 45% of observed urinals are tilt tray devices). Porcelain bowl urinals with demand valve flushing devices were found to occur mainly in primary schools and staff ablutions.

The data indicates that 11% of fittings observed in primary schools were leaking or out of order, compared with 8% in secondary schools.

Taps left running were found only in primary school ablutions, supporting the hypothesis that junior learners are easily distracted, forgetting to shut off bib taps, or are physically unable to close the tap.

4.9 Life cycle costs of alternative installation components

Improvement of the installed technology within school ablutions will reduce water consumption, as illustrated in the life cycle calculations in the following example.

This example compares the installation of urinals in male learners' ablutions, suitable for a school of 1000 learners, based on the requirements of the National Building Regulations (NBR). Table 7 of Part P. Drainage, of the NBR, indicates that a school of 1000 learners would require 12 urinal stalls. One urinal stall is equivalent to a single bowl urinal, or 600mm width of a slab urinal. The following calculations are based on two 3600 mm slab urinals, compared against 12 individual bowl urinals.

Table 19: Life cycle cost - Stainless steel automatic flushing urinal installation

	Extent		Rate	Amount
Capital cost				
Stainless steel urinal 3600 long	2	No	4,200.00	8,400.00
Urinal trap	2	No	120.00	240.00
15mm Stopcock	2	No	120.00	240.00
Connect to 15mm supply	2	Item	50.00	100.00
Connect to 40mm waste	2	Item	50.00	100.00
				R 9,080.00
	Frequency		**Cost**	
Operating cost				
Maintenance:				
Inspect timing and adjust flow controller	6	months	25.00	
Water use:				
Volume per flush	5	litres		
Flushing cycle	15	minutes		
Water consumption per year	350	kilolitres		
Life Cycle Cost				Rands
Capital cost				9,080.00
NPV of Replacements				-
NPV of Maintenance				771.67
NPV of Water consumption				17,066.55
Salvage cost				-
TOTAL LIFE CYCLE COST:				**R 26,918.22**

Table 20: Life cycle cost – Push button flushing bowl urinal installation

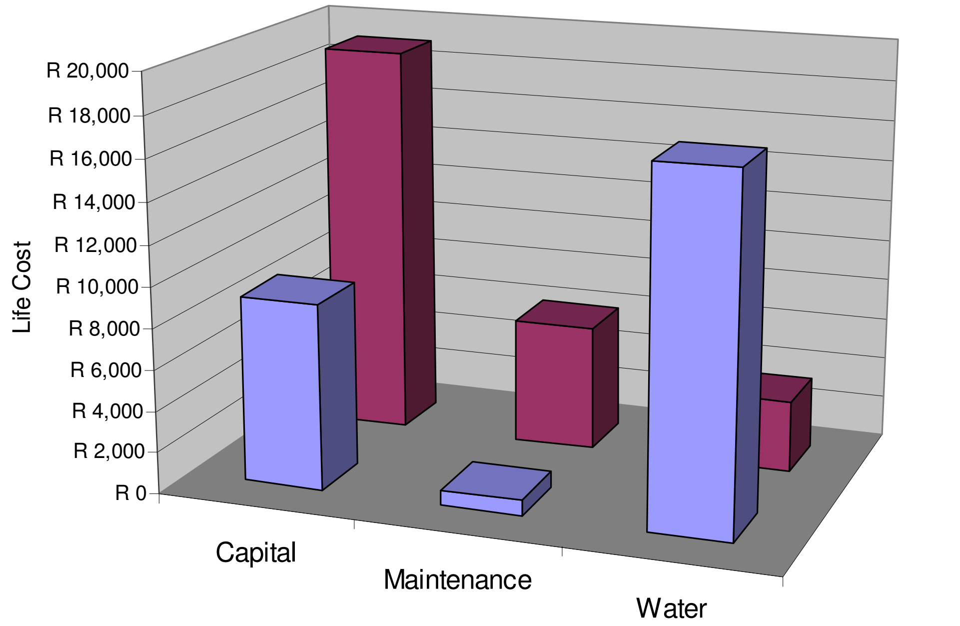
	Extent		Rate	Amount
Capital cost				
Bowl urinal	12	No	1,550.00	18,600.00
Flushmaster Junior flash valve	12	No	-	-
Chromium plated urinal trap	12	No	-	-
15mm Stopcock (banks of 6 bowls)	2	No	120.00	240.00
Connect to 15mm supply (ditto)	2	Item		100.00
Connect to 40mm waste (ditto)	2	Item		100.00
				R 19,040.00
	Frequency		Cost	
Operating cost				
Maintenance:				
Inspect timing and adjust flow controller	6	months	25.00	
Service flush valve - replace kit	5	years	100.00	
Water use:				
Volume per flush	1	litres		
Flushes per day per urinal	41	flushes		
Available days (school days)	147	days		
Water consumption per year	72	kilolitres		
Life Cycle Cost				Rands
Capital cost				19,040.00
NPV of Replacements				-
NPV of Maintenance				6,111.53
NPV of Water consumption				3,485.85
Salvage cost				-
TOTAL LIFE CYCLE COST:				**R 28,637.38**

Table 19 and Table 20 above illustrate the comparative life cycle costs of the two installation alternatives described. Note that the projected lifespan of all components were assumed to exceed the capitalization period, given that flush valves have been allowed to be completely refurbished every 5 years, in Table 20. No salvage value has been allowed for either installation. The total water consumption tariff has been derived as follows:

Water consumption charge	R 5.26 per kilolitre
Sewerage disposal charge	R 0.95 per kilolitre of water consumption
TOTAL:	R 6.21 per kilolitre

Net present value is calculated using a nominal rate of 12% per annum over a 25 year period.

Figure 24 clearly demonstrates the significant differences in components of life cycle costs of the two alternatives. This leads to the conclusion that whilst capital cost of individual bowl urinals is significantly higher than the slab urinals, the life cycle cost of water is higher for the slab urinals.



	Capital	Maintenance	Water
Autoflush slab urinal	R 9,080.00	R 771.67	17,066.55
Bowl urinal	R 19,040.00	R 6,111.53	3,485.85

Figure 24: Comparative life cycle cost of urinal installations

The analysis shown in Figure 24 illustrates the sensitivity of comparative life cycle cost to the consumption cost of water.

This sensitivity has been calculated, and is tabulated and graphed in Table 21 and Figure 25 below, showing the break even point of “consumption cost of water” for this combination of installation components as R7.20 per kilolitre:

Table 21: Sensitivity of life cycle costing to total water consumption tariff

	Total Life Cycle Cost	
Total water and sewer tariff:	Slab	Bowl
	R 26,918.22	R 28,637.38
R 5.00	R 23,592.85	R 27,958.17
R 5.50	R 24,966.97	R 28,238.83
R 6.00	R 26,341.09	R 28,519.50
R 6.50	R 27,715.20	R 28,800.16
R 7.00 – break even point	R 29,089.32	R 29,080.83
R 7.50	R 30,463.44	R 29,361.49
R 8.00	R 31,837.56	R 29,642.16
R 8.50	R 33,211.68	R 29,922.82
R 9.00	R 34,585.79	R 30,203.48
R 9.50	R 35,959.91	R 30,484.15
R 10.00	R 37,334.03	R 30,764.81

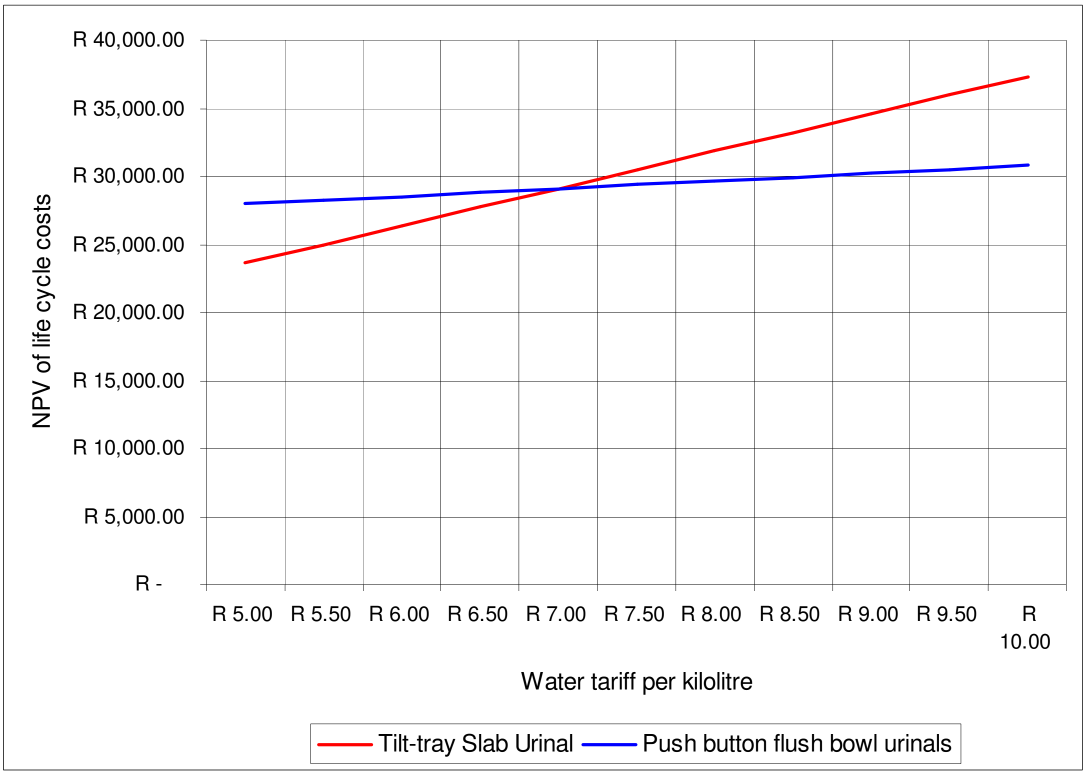


Figure 25: Sensitivity of life cycle cost to total water consumption tariff

The cost of removal and replacement of slab urinals with bowl urinals may be unaffordable to most schools, given the financial pressures already being experienced by these institutions. Alternative means of reducing water therefore need to be identified. McKenzie et al (2002) used this alternative approach in the pilot upgrade projects undertaken at various sample schools. During this Rand Water sponsored project, existing automatic flushing slab urinals were retrofitted with push button demand valves, coupled to a sparge pipe along the top edge of the urinal. The life cycle benefits of such a retrofit are calculated in Table 22 and Table 23 below.

Figure 26: Modified urinal flushing mechanism

Table 22: Life cycle cost of existing automatic flushing slab urinal (two 3600mm urinals)

Operating cost	Frequency		Cost	
Maintenance:				
Inspect timing and adjust flow controller	6	months	25.00	
Water use:				
Volume per flush per urinal	5	litres		
Flushing cycle	15	minutes		
Water consumption per year	350	kilolitres		
Life Cycle Cost (2 x 3600mm urinals)				
Capital cost				Existing
NPV of Replacements				-
NPV of Maintenance				771.67
NPV of Water consumption				17,066.55
Salvage cost				Excluded
TOTAL REMAINING LIFE CYCLE COST (excludes any residual capital in the existing installation)				**R 17,838.22**

Table 23: Life cycle cost of retrofitting existing automatically flushing urinals (two 3600mm urinals)

	Extent		Rate	Amount
Capital cost				
Flushmaster demand valve	2	No	990.00	1,980.00
15mm Stopcock	2	No	120.00	240.00
Connect to 15mm supply	2	Item		100.00
				R 2,320.00
	Frequency		Cost	
Operating cost				
Maintenance:				
Inspect timing and adjust flow controller	6	months	25.00	
Service flush valve - replace kit	5	years	100.00	
Water use:				
Volume per flush	5	litres		
Flushes per day	41	flushes		
Available days	147	days		
Water consumption per year	12	kilolitres		
Life Cycle Cost				
Capital cost				2,320.00
NPV of Replacements				-
NPV of Maintenance				1,018.59
NPV of Water consumption				2,904.88
Salvage cost				-
TOTAL REMAINING LIFE CYCLE COST (excludes any residual capital in the existing installation)				**R 6,243.46**

Table 22 and Table 23 demonstrate the significant financial savings to be derived by schools, by retrofitting certain wasteful installation components within their premises. The calculations in Table 23 are based on the installation of one demand valve per 3600 mm urinal, being flushed a reduced number of times (assuming that only one in six users will press the flush valve) as illustrated in Figure 26.

Figure 27:Automatic flushing slab urinal

Figure 28:Demand flush bowl urinal

4.10 The effect of water saving devices in a school

Based on the school configuration used in Table 19 to Table 23, and applying the algorithms designed by Konen & Stevens (1986) described on page 20 (See Table 24), the estimated water consumption in the school ablutions, assuming conventional fittings are installed, would be as modeled below in Table 25 (excluding losses from leakage, poor management and vandalism):

Table 24: Modelling of ablution use - loading assumptions

Ablution loading and Component Provision	Male				Female		
		WC	Wash basin	Urinal		WC	Wash basin
Uses per ablution use		0.33	0.96	0.67		0.96	0.96
Uses per person per 9-hour office day	2.18				3.08		
Uses per 6-hour school day	1.45				2.05		
Population	500				500		
School days per year	147				147		
Components installed (based on National Building Regulations: Part P – Drainage (Table 7)		3	4	2		16	7

Table 25: Modelled ablution water use - conventional component installation

Conventional Installation	Male				Female		
		WC	Wash basin	Urinal		WC	Wash basin
WC flush (litres)		11				11	
WC consumption per annum (kilolitres)		387				1,591	
Urinal flush volume (litres) Flushing cycle (minutes)				5 15			
Urinal consumption per annum				350			
Bibtap flow rate (litres / minute) Wash duration (seconds)			20 10				20 10
Wash basin consumption per annum			341				482
TOTAL WATER USE PER ANNUM	728				2,073		
Total water consumption per annum (kilolitres)				2,801			
Consumption per FTE (litres / annum)				19.1			

Substituting water efficient devices into this modeled environment, the effective water consumption in the ablutions would be as shown in Table 26. These water efficient devices are assumed to be:

WC Suites – substitute conventional 11 litre cisterns with 6 litre cisterns. The WC pan must be capable of accommodating a 6 litre flush. Certain pans are not designed to work with low volume flushes, rendering them unsuitable for cistern upgrades. When specifying new installations, the specifier should carefully match the selected cistern with a suitable pan.

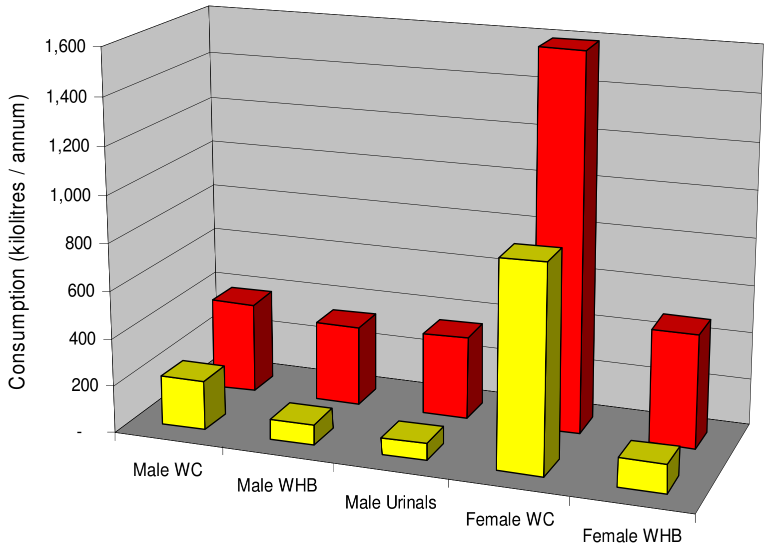
Urinals – substitute twelve push-button bowl urinals in lieu of two 3600mm automatic flushing stainless steel slab urinals.

Bib taps on wash basin fitted with 5 litre per minute flow restrictors. This presupposes that the bib taps, in the case of a retrofit, are capable of receiving threaded flow controllers on their spouts. When specifying new equipment, specifiers should select taps with threaded flow-straighteners, capable of being replaced with threaded flow restrictors. Existing taps may be retrofitted with internal flow restrictors. Various types of these are available from local suppliers.

Table 26: Modelled water consumption using water saving devices

Water Saving Installation	Male			Female	
	WC	Wash basin	Urinal	WC	Wash basin
WC flush (litres)	6			6	
WC consumption per annum (kilolitres)	211			868	
Urinal flush volume (litres)			1		
Urinal consumption per annum			71		
Bibtap flow rate (litres / minute)		5			5
Wash duration (seconds)		10			10
Wash basin consumption per annum		85			121
TOTAL WATER USE PER ANNUM	296			988	
Total water consumption per annum (kilolitres)			1,285		
Consumption per FTE (litres / annum)			8.7		

Whilst not clearly supported by the results shown in column "H" of Table 16, the estimated reduction in water use in these ablutions is approximately 57%, representing a significant life cycle cost saving to the school. These calculations therefore clearly exceed the Hypothesis 3 statement that "Low water demand technologies fitted in school ablutions will reduce ablution water use by 15%".The comparative water use by various components is graphed in Figure 29 to illustrate the magnitude of the impact of these various water saving options.



	Male WC	Male WHB	Male Urinals	Female WC	Female WHB
Water Saving	211	85	71	868	121
Conventional	387	341	350	1,591	482

Figure 29: Water saving impacts in ablutions

Figure 30: An innovative conversion solution for urinals!

This study derives occupant consumption per FTE as 25 litres per FTE per annum. (See section 4.5). The calculation carried out in Table 25 suggests that the ablution consumption component of this 25 litre per FTE is 19 litres per annum. The remaining 6 litres per FTE per annum would therefore be comprised of water used in the following:

- Occupant consumption (drinking);
- Facility cleaning;
- Educational use in laboratories and art rooms;
- Leakage and wastage.

Estimating water loss at 25%, that is 6 litres per FTE per annum, we conclude that the quantities of water used for drinking, cleaning and educational use are inconsequential.

4.11 Summary

This chapter has yielded much useful information relating to the resolution of the research problem and sub-problems. To reiterate, the research problem was formulated as follows:

Can a model be developed for baseline calculations of water consumption in South African schools?

This problem was sub-divided into sub-problems, with their relevant hypotheses, as follows:

Sub-problem 1: *How much water is consumed by the core education-related processes occurring in schools?*

Hypothesis 1: *Based on the findings of Robson (1966), the water consumption per learner Full-Time Equivalent (FTE), resulting from learning and ablution processes, will account for 21 litres per FTE per annum.*

Table 14 on page 53 calculates the consumption per FTE as 25 litres per annum, supporting this hypothesis. Whilst this result may appear rather simplistic, it is derived from a model constructed in section 4.6.1 based on the calculation of total facility FTE population per annum, from population statistics supplied to the model.

Sub-problem 2: *How much water is consumed in the irrigation of landscaped gardens and sports fields?*

Hypothesis 2: *Based on the findings of Tondut (1976), the daily water consumption per FTE, resulting from irrigation of external areas, including sports grounds, will account for 63 litres per FTE per annum.*
Metering and timing of irrigation systems will reduce irrigation use by 20%.

Based on the total estimated water consumption of 61 litres per FTE per annum (See summary of Table 16), and applying the percentage derived in Figure 18, irrigation accounts for only 32 lites per FTE for the total of modeled consumption for the sample. This may result from the large influence of previously disadvantaged schools, or "township schools", where the incidence and extent of sports fields and landscaped gardens is minimal.
Irrigation consumption stated here is based on the model constructed in section 4.6.2 on page 56, using the total school population statistics and other variables as inputs into the model.
No data was collected on the presence of metering and timing systems at the sampled schools. The second part of this hypothesis therefore remains unanswered.

Sub-problem 3: *How does the installed technology influence water use in schools?*

Hypothesis 3: *Low water demand technologies fitted in school ablutions will reduce ablution water use by 15%.*
Water losses, due to faulty installations and leakages, will account for an average of 30% of total water consumption.
Secondary schools will consume more water per FTE than Primary Schools, due to higher incidence of vandalism and larger sports facilities.

Whilst not clearly supported by the results shown in column "H" of Table 16, section 4.10 on page 73 calculates the estimated reduction in water use using water-efficient fittings as approximately 57%. These calculations therefore clearly exceed the Hypothesis statement that "*Low water demand technologies fitted in school ablutions will reduce ablution water use by 15%*".

Table 16 on page 58 calculates the average estimated losses, from the model, due to leakages and under-metering is 29,5%. This supports the hypothesis that water losses, due to faulty installations and leakages, will account for an average of 30% of total water consumption. This is confirmed again by the results of Figure 18 on page 60.

In terms of the relative performance of primary schools, compared against secondary schools, Figure 19 illustrates and lists central tendency of water consumption per FTE. The large difference in average consumption may be largely due to the difference in areas of sports fields per learner at Secondary Schools, as illustrated in Figure 20. Figure 20 was calculated using the model for areas of sports fields and landscaped gardens and lawns constructed in 4.6.2 on page 56. This confirms the Hypothesis that "*Secondary schools will consume more water per FTE than Primary Schools, due to higher incidence of vandalism and larger sports facilities*", although an analysis of loss by vandalism has not been included in this study.

The research problem can, therefore, be adequately answered in that a model has been successfully developed to calculate baseline water consumption for schools. This model is consolidated into a modeling tool in Appendix F of this document. The tool is constructed from the findings and derived models in section 4.6 and is intended for use by school facilities management for the purpose of calculating estimated water consumption for management comparison with actual metered usage.

CHAPTER 5: KEY FINDINGS, COMMENTS AND RECOMMENDATIONS

5.1 Key performance indicators and water use simulation

Data analysis carried out during this project has provided useful water consumption indicators for schools. These water consumption indicators have been incorporated into a paper based water use simulation tool, attached in Appendix F. This tool allows school managers to calculate estimated water consumption, based on input variables entered onto the forms. The simulation tool guides users through the calculation processes, some fairly complex, to derive a projected, or estimated, water use for the school. The simulation tool takes the following into account:

- Population loading of the school, including learners, staff, community users, hostel boarders and staff accommodated on site;
- Number of sports fields on the site;
- Extent of gardens and lawns;
- Condition of landscaping;
- Extent of mains irrigation.

The tool has been handed to the Department of Water Affairs and Forestry for distribution to schools, through their association with the National Education in the Environment Programme (NEEP), together with a recommendation that the tool be used by schools nationally to establish targets for their water conservation projects, as well as to provide the Department with a baseline of schools water use before embarking on water saving initiatives and programmes in various provinces.

5.2 Metering

Accurate and consistent metering of water consumption is the key to the successful management of water use in the school. This project, and projects described in literature, has encountered a remarkably high incidence of metering failures or shortcomings in the utility billing system. Schools without suitable metering facilities are not able to measure or monitor water use, nor monitor the effects of water savings interventions within their facilities.

Linked to the availability of accurate metering, is the ability of the water consumer to log their mains supply. The logging exercise allows the user to identify “night flows” and other similar extraneous water use. In order for logging to be carried out, the main incoming supply meter, or client-side equivalent meter, must be fitted with pulsing facilities which allow the installation of pulse logging equipment. Logging also requires the temporary installation of sensors and loggers to the meter, which in many cases is well exposed to learners and the public. This equipment is costly, and vulnerable to vandalism, so requires protection in the form of a buried meter chamber, or lockable steel cage.

If the school should consider investing in loggable metering equipment at their boundary, a number of related issues should be borne in mind:

- As described by Chapman (1997), the reduction of supply pressure will lead to the reduction of water loss through leakage, but will also reduce wear and tear on certain installation components. For this reason, a pressure reducing device should be fitted to the incoming main, during the installation of a new meter;

- Many of the water saving interventions in ablutions-type facilities require the installation of sensitive equipment, such as demand valves (flushing devices to urinals and WC suites), flow restrictors to basin taps, and specialist irrigation equipment. These devices are susceptible to blockage from water borne debris carried through the mains supply. The installation of a water strainer, at the main incoming supply, would assist the school in protecting their investment in water installation upgrade components, as well as protecting the water meter from damage from such debris. This device should be regularly serviced, given that it collects major debris from the main supply, and should be placed so as to be accessible to the school maintenance team. The strainer should be positioned before the school's water meter. Locally available strainers are fitted with casings which are interchangeable with a water meter mechanism, which can be fitted, operated and logged in parallel with the main meter. This is useful for the regular calibration of the school's own meter. Discussions held with plumbing specialists have also suggested that smaller diameter water strainers be fitted onto supply branches feeding flush valves and flow controllers. This argument is supported by the fact that the main strainer at the incoming supply is generally fairly coarse, and will not collect all debris harmful to the installation. These sub-strainers should also be suitably accessible for maintenance purposes.

- Local authorities generally are considering the inclusion, within by-laws, of non-return equipment (backflow prevention) at the incoming main supply. This prevents water from the client installation from returning into the main supply, should the main supply pressure drop, or fail. This equipment could also be fitted at the time of the meter installation, or provision made for later installation, using a removable straight length of piping near the meter.

5.3 Facility management

Given that the school has been equipped, or enabled, to effectively measure water consumption, the school management should implement a regular and consistent monitoring routine. This routine could include participation by the learners and staff, integrated into the schools' academic curriculum. The danger with excessive reliance on learners is that during school holidays, and examination days, the monitoring process may falter. A simple meter reading routine should be incorporated into the caretaker's duties, with water consumption recorded daily in a prominent position within the school, or administration, with procedures to be followed in case of large deviations from targeted consumption.

In addition to monitoring of consumption from the mains supply, irrigation of sports fields should be closely monitored. Stone (1978) suggests that over watering of landscaping is a major contributor to excessive water use in some facilities. Stone recommends the installation of moisture sensing equipment, to monitor moisture levels in the soil. This may be a costly solution for schools. The simple monitoring of rainfall, using a low cost rain gauge, would allow the grounds man to assess the additional water to be applied to sports fields during a 7-day cycle. The South African Irrigation Institute (2003) suggests that overhead irrigation supplies water to the landscape at a rate of approximately 5mm per hour, given a number of system design variables such as soil infiltration rate, supply pressure and overlap between sprinklers.

5.4 Further research

The following areas encountered during this project may lend themselves to further research:

5.4.1 Correlation between facility condition and facility water losses

Assessment of facility condition was not successfully achieved during this project. As a result, no firm correlation could be determined between general state of facility repair (facility condition) and water losses occurring throughout the facility. Condition assessment may also need to take cognisance of age of the facility (and therefore, possibly, the underground reticulation) and construction era (to determine prevalent technologies at time of construction).

5.4.2 Irrigation of sports facilities and landscaping

Figure 18 shows that 45% of the schools' water use is generally used for the irrigation of sports fields and landscaped gardens and lawns. Given that these facilities are becoming increasingly important, not only to the schools, but to the communities that they serve, the complex relationships between the various elements of the landscaping require detailed investigation. These elements include the selection of grass type, soil preparation, irrigation technology employed and installed, operational management of the grounds (mowing, fertilizing, etc.) and the measurement and monitoring of moisture content in the soil.

The Department of Education recently carried out a pilot audit of sports facilities within their schools, with a view to the development of national policy on school sports provisioning. The construction and management of these sports facilities will become critical to the success of their sports implementation plans, as these unfold during the next few years. Additional water demand on schools and communities will require careful monitoring, to avoid wastage of this precious commodity.

5.4.3 Water saving technologies

During the completion of this project, and indeed for many years before, a number of Non-Governmental Organisations (NGOs), equipment suppliers and water supply authorities have touched on schools as a means of raising awareness relating to water conservation and the efficient use of water. Some of these organisations have installed water saving technologies within their pilot schools. Valuable research could be carried out to report on the effectiveness of these projects, a number of years after installation, with regard to maintenance, operational management, water saving and vandalism. This feedback would be valuable, not only to those project sponsors, but to schools in general, who are continuously searching for cost effective ways of reducing operational costs.

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Appendix A: List of schools in the sample set with GIS representation

Appendix B: Site audit questionnaire

Appendix C: Total Full Time Equivalent per annum per school

EMIS Number	School Name	Total FTE
260018	ASTON MANOR PRIMARY	153,876
230185	BURGHER RIGHT PRIMARY	183,736
230201	CAPITAL TUTORIAL COLLEGE	13,916
250092	CONSTANTIA KLOOF PRIMARY	149,371
231605	DAVID HELLEN PETA SECONDARY	156,310
241109	DIMAKATSO PRIMARY	144,946
250118	DISCOVERY PRIMARY	179,250
240630	DITHABANENG PRIMARY	63,508
260091	EDLEEN PRIMARY	150,871
220624	EZAZI PRIMARY	62,034
231670	FLAVIUS MAREKA SECONDARY	166,102
260109	HOëRSKOOL BIRCHLEIGH	125,766
210187	HOëRSKOOL GARSFONTEIN	227,319
250241	HOëRSKOOL JAN DE KLERK	114,200
250266	HOëRSKOOL NOORDHEUWEL	231,009
220178	HOëRSKOOL OOS-MOOT	214,175
220186	HOëRSKOOL SILVERTON	118,207
220194	HOëRSKOOL STAATSPRESIDENT C R SWART	107,996
260877	INQAYIZIVELE SECONDARY	287,867
260901	IPONTSHE PRIMARY	175,423
220707	JAFTA MAHLANGU SECONDARY	164,463
260984	KHATLAMPING PRIMARY	158,117
240804	KHENSANI PRIMARY	86,615
260992	KHULA SIZWE PRIMARY	142,135
210641	LAERSKOOL BAKENKOP	136,476
230813	LAERSKOOL DANVILLE	78,128
250639	LAERSKOOL DR HAVINGA	242,842
250662	LAERSKOOL FLORIDA	126,596
250688	LAERSKOOL GUSTAV PRELLER	76,959
250720	LAERSKOOL HORISON	151,313
220343	LAERSKOOL NELLIE SWART	44,228
260422	LAERSKOOL NOBEL PRIMARY	113,908
220368	LAERSKOOL RIETFONTEIN-NOORD	88,754
260430	LAERSKOOL VAN RIEBEECKPARK	187,662

EMIS Number	School Name	Total FTE
230052	LAUDIUM HEIGHTS PRIMARY	131,849
220749	LEHLABILE	224,714
240895	LETHABONG SECONDARY	116,531
210906	LYTTELTON MANOR HIGH	161,600
231878	MABAFENG PRIMARY	144,917
231910	MAKGWARANENG PRIMARY	141,893
231928	MANGENA MOKONE PRIMARY	46,116
231936	MAREMATLOU PRIMARY	60,775
220855	MODIRI TECHNICAL	116,407
220863	MOGALE PRIMARY	150,744
250860	MONUMENT PRIMARY	172,278
261123	MVELAPHANDA PRIMARY	128,840
241026	NTSAKO SECONDARY	189,984
260885	PHOMOLONG PRIMARY	324,363
231316	PRETORIA BOYS' HIGH	597,907
250969	PRINCESS PRIMARY	159,132
241141	REDIBONE PRIMARY	66,738
231373	RIETONDALE PRIMARY	157,469
241166	RODNEY MOKOENA PREPARATORY	252,743
261685	SHANGRI-LA ACADEMY	90,850
261206	SHUKUMANI PRIMARY	127,929
221093	SIKHANYISELE PRIMARY	74,823
251025	SILVERFIELDS PRIMARY	101,127
260810	SPARTAN HIGH	46,015
211086	ST MARY'S DIOCESAN FOR GIRLS	243,129
261370	TLAMATLAMA PRIMARY	207,306
241497	UBUHLE-BEZWE JUNIOR SECONDARY	134,954
261420	UMQHELE COMPREHENSIVE	331,049
221168	UMTHOMBO PRIMARY	49,539
211235	WILLOWRIDGE HIGH	179,407

Appendix D: Rainfall and irrigation simulation for Pretoria

Appendix E: Notification letter to schools

Appendix F: Paper based water-use simulation tool for schools