5: Technical Resolution

'I'm very interested in buildings that adapt to changes in climatic conditions according to the seasons … I am concerned about the exploitation of the natural environment in order to modify the internal climate of buildings. Architects must confront the perennial issues of light, heat, and humidity control yet take responsibility for the method and the materials by which, and out of which, a building is made. The considerations, context, and the landscape are some of the factors that are constantly at work in my architecture.'

Glenn Murcutt, quoted in Jensen & Walker, 2002. *Glen Murcutt: A Singular Architectural Practice*, p 33)

5.1 Sustainability: Baseline document

The Sustainable Building Assessment Tool (SBAT) was developed to assess the sustainability of a building according to certain economic, social and environmental criteria. The Sustainable Buildings Group of the division of Building and Construction technology, CSIR, Pretoria, designed this device. It was developed for use in third world countries and includes aspects such as the impact of the building on the local economy. The application of SBAT is not building-type specific, and it can be used for assessment of offices, factories, clinics, housing etc. (Gibberd: 2002).

For the Inter*active* Centre to provide a safe, healthy and inclusive environment, the design must conform to the recommended sustainable measures. The objectives that apply to this project are set out below; these parameters are based on SBAT and the National Building Regulations (NBR).

5.1.1 BASELINE OBJECTIVES

The baseline objectives serve as a guide for design decisions and technical resolutions by prioritising certain qualities of the Centre. For example, as the context of the project is a Nature Reserve, the environmental performance is more important than the economic performance (Figure 79).

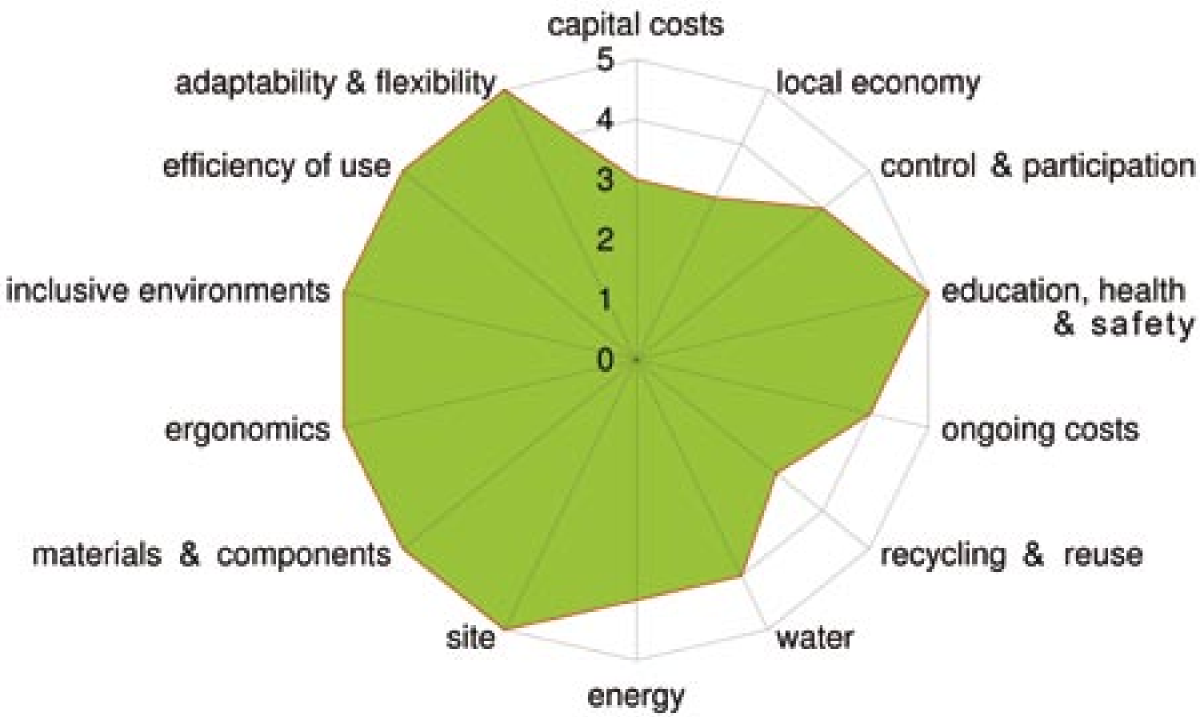
5.1.2 SOCIAL CRITERIA

5.1.2.1 Ergonomics & inclusive environments

The Centre should be accessible to all users to ensure an inclusive environment. The design should provide for easy access and use by disabled persons, the elderly and children. As the Centre has a multidimensional user profile (Figure 17), the design must be adaptable and provide solutions that are not restricted to a single group of users.

The safety and accessibility requirements of the SABS 0246 were met, especially with regard to level changes. Ramps of 1:12 fall are to be provided at all level changes and should have balustrades on both sides. According to SABS 0246 p 7, the minimum clear opening of all doorways for use by disabled individuals is 750mm. Throughout the Centre the minimum width (Figure 80, **X**) of corridors and door openings is 900mm to make it comfortable for cyclists to steer their bicycles through the necessary points to reach the bicycle stands (cf 4.4.8.4).

Slippery floors are hazardous for people whose sight is impaired therefore the use of non-slip floor materials should be used where possible. Contrasting textures and colours in floor materials should be incorporated to help people with impaired vision distinguish between changes in floor levels,



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changes in direction (balustrades) and areas with different functions.

Throughout the Centre there are points where a mountain biker can leave a bicycle while attending a lecture, drinking coffee, viewing the exhibitions or browsing in the shops. This implies that the exterior as well as interior floor finishes have to be as accessible as possible. To propel a bicycle or wheelchair, for example, over thick pile carpets, loose sand or stone aggregate is extremely difficult and therefore these finishes should be avoided.

Providing facilities for the disabled is an important aspect of inclusive design. Catering for the physically impaired and wheelchair users includes the provision of well-designed, flush-valve toilet facilities as well as lowered counters and information desks. Provision for the visually impaired also means allowing guide dogs into the Centre and if required, providing water bowls. Guide dogs have to be prohibited from entering the reserve outside the Centre, however, as they may disturb the wildlife.

5.1.2.2 Occupant comfort

Noise from the R21 highway is at times audible within the reserve and can distract the visitors especially when a lecture is in progress in the auditorium. The water feature on the eastern side of the auditorium addresses this issue, along with the use of sound-absorbing materials and materials with high mass. An acoustic engineer's assistance is required to resolve all matters in this regard.

Thermal comfort and ventilation in the Centre are vital in creating a healthy and comfortable environment. With Pretoria's low average humidity, a constant temperature of between 22°C and 24°C is ideal. Mechanical heating and cooling does not provide an energy-efficient solution and is unnecessary if the spaces can be passively ventilated. If possible, mechanical ventilation should be limited to the coffee shop kitchen and the public toilets.

5.1.2.3 Safety & Fire Protection

Security guards at the gates control access to the reserve. The fee that is charged upon entrance is by way of a security measure and added to this the personnel at the point of entry within the Centre (exhibition area) monitor the inflow of visitors.

Signage that indicates fire equipment in the Centre should be clear and visible as according to SABS 1186. Installation of fire hose reels are to comply with SABS 543. All fire escape doors are to open in the direction of escape and escape routes are to be at least 800mm wide.

5.1.2.4 Education

The visitors to the Centre include families and learners. The youth, in particular, must be made aware of environmental issues and civic pride. This educative process can be achieved by means of audio-visual exhibitions, posters and suitable lectures.

5.1.3 ENVIRONMENTAL ISSUES

5.1.3.1 Energy

The choice of lamps in the Centre should be influenced by cost (capital and running cost), and quality of light in terms of colour rendering and glare. The use of lamps with a long life span will minimize the running cost and maintenance of the Centre and will use less energy, which is a part of an environmentally responsible design.

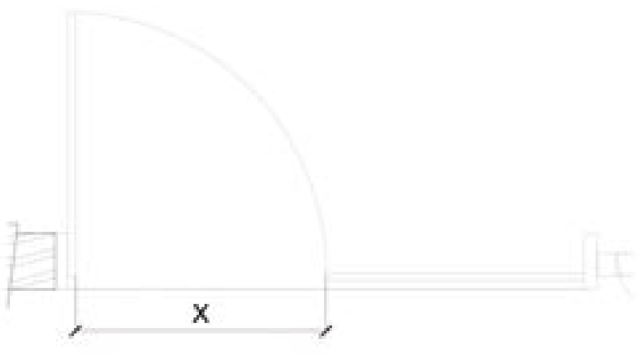
Passive ventilation as opposed to a mechanical ventilation system as well as good maintenance and management of the systems of the Centre (sound, lighting, services) will decrease the energy use of the Centre.

5.1.3.2 Waste management & deliveries

An area is allocated in the Centre where all waste is to be sorted. This area is at the back of the coffee shop kitchen

Figure 79: The baseline objectives are prioritised in the Inter*active* Centre

Figure 80: Clear width of doorways in the Centre



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(Figure 51). Organic waste like leftover food from the eatery can perhaps be exchanged for compost with a local farmer. Glass, paper and tin are to be separated and recycled.

The same area serves as the point where goods are delivered to the coffee shop. The access roads to the delivery area are not to be obstructed by sign boards, cars or bicycles. Deliveries are not to be made at the main entrance of the Centre, as this will disturb visitors.

Stainless steel waste and garbage bins are situated in combination with signage throughout the Centre and are to be emptied daily.

5.1.3.3 *Recycling and re-use of materials*

In 'Concepts for Recycling Construction/ Demolition Materials', in *Sustainable Construction* (1994:269), Lozar comments 'There is now a groundswell of interest in the design of buildings and the choice of their materials and construction so that they may be readily deconstructed. Thus, the full lifecycle of the material is considered and used in such a way as to facilitate use and re-use'.

The use of recyclable materials minimises the building's ecological footprint so as far as possible materials should be chosen that can be re-used or recycled and have a low embodied energy.

The following are examples of re-useable materials in the design of the Centre:

- reeds available within the reserve are used in Product C
- the open-air classroom seating makes use of old railway sleepers
- the corrugated sheeting of the existing lapa is re-used as roofing material

Concrete is used as roofing material and for flooring throughout the Centre.

According to the Portland Cement Association and the Environmental Council of Concrete Organisations, concrete is a sustainable material because

- it causes minimal waste as it is produced in the exact quantities needed for the project
- it is cast on site and is therefore labour intensive and creates job opportunities
- it is durable and gives the building thermal mass
- it reflects natural light for effective day lighting
- it retains storm water

Bamboo flooring panels is used in the auditorium and apart from the aesthetic and acoustic (cf. 5.2.3) value of the material, the material has several environmental advantages.

Bamboo is:

- a rapidly renewable resource
- harvested with virtually no impact on its natural environment
- a low-emitting material if not finished with formaldehyde

Ecostrong bamboo flooring is a South African supplier, which is specified for the auditorium. Their product is 30 % harder than oak timber flooring, minimizing the wear that occurs due to furniture, shoes and bicycles.

5.1.4 ECONOMIC ISSUES

5.1.4.1 *Local economy*

The use of scarce materials should be avoided. The use of South African manufactured or supplied products supports the local economy and this has been recognised in the project.

To name a few South African products specified for the Centre:

- Ecostrong bamboo flooring
- Matco PVC tiles
- Dykor ceramic tiles
- Maizey's acrylic panels
- PG Bison chipboard and Surinno solid surfacing
- Rondo kitchenware
- Floor Crete/ Flexi bond concrete finishes

Local labour and the use of indigenous materials (brickwork, concrete, stone, reeds and timber) are to be used for construction, shop-fitting and product manufacturing.

The employment and training of local workers for catering, maintenance and as veld guides is to be encouraged. By incorporating an arts and crafts shop local entrepreneurs can be empowered and supported.

5.1.4.2 *Adaptability and flexibility*

The Centre represents a large investment by private and governmental bodies, which makes it unlikely that the structure will change to alter the function of the building within the first 5 years. More structures may well be added over time so the lifespan of materials and commercial ventures should be taken into consideration along with recycling and re-use possibilities. Installations and fittings are to be flexible, easy to assemble, remove and re-use.

5.1.4.3 *Ongoing costs*

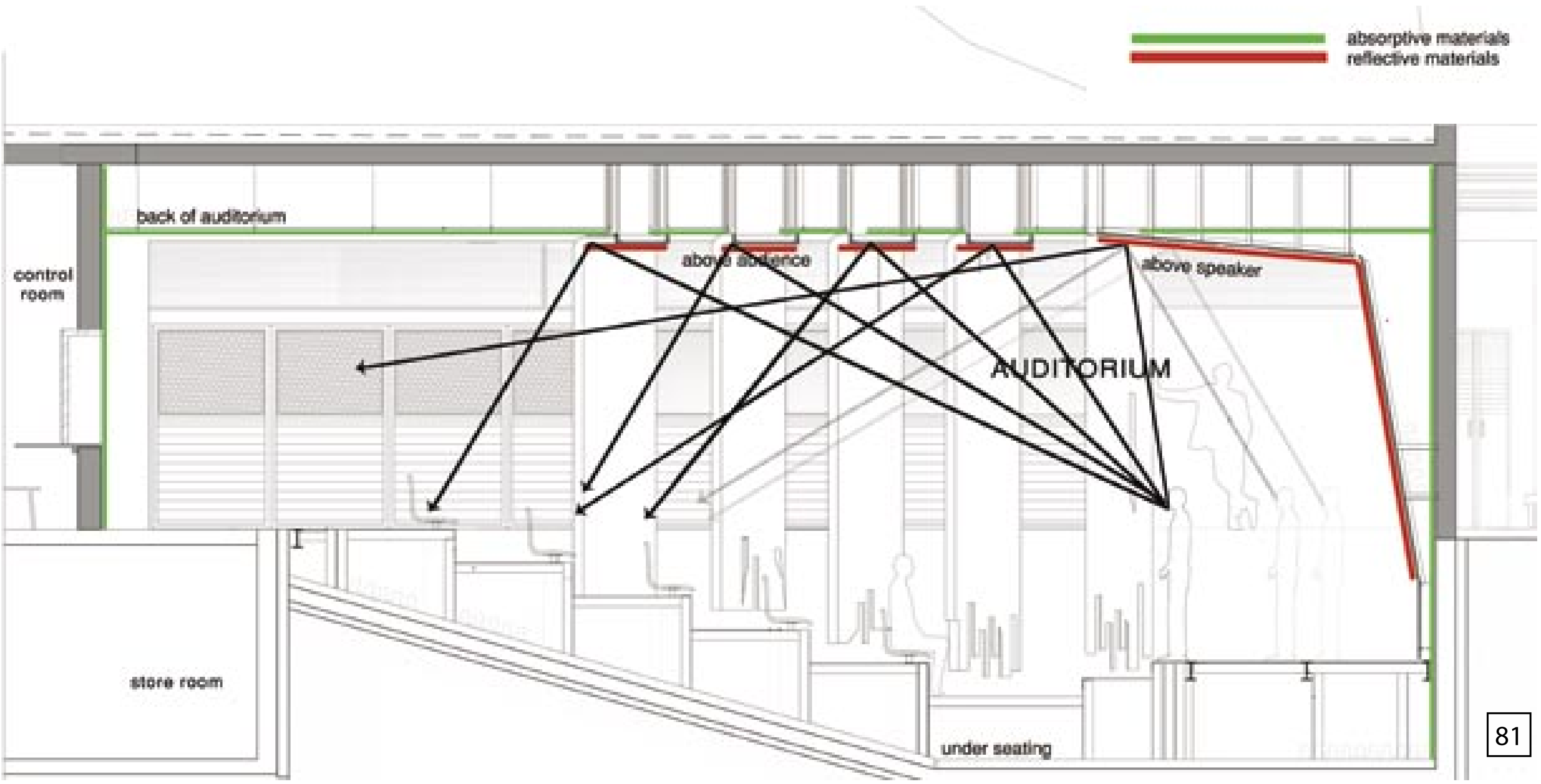
The building manager should take care that regular inspections are made of the fixtures and services at the Centre. Through correct maintenance and control of the building lighting, sound and computer systems, the need for repairs can be limited, which will minimise ongoing costs.

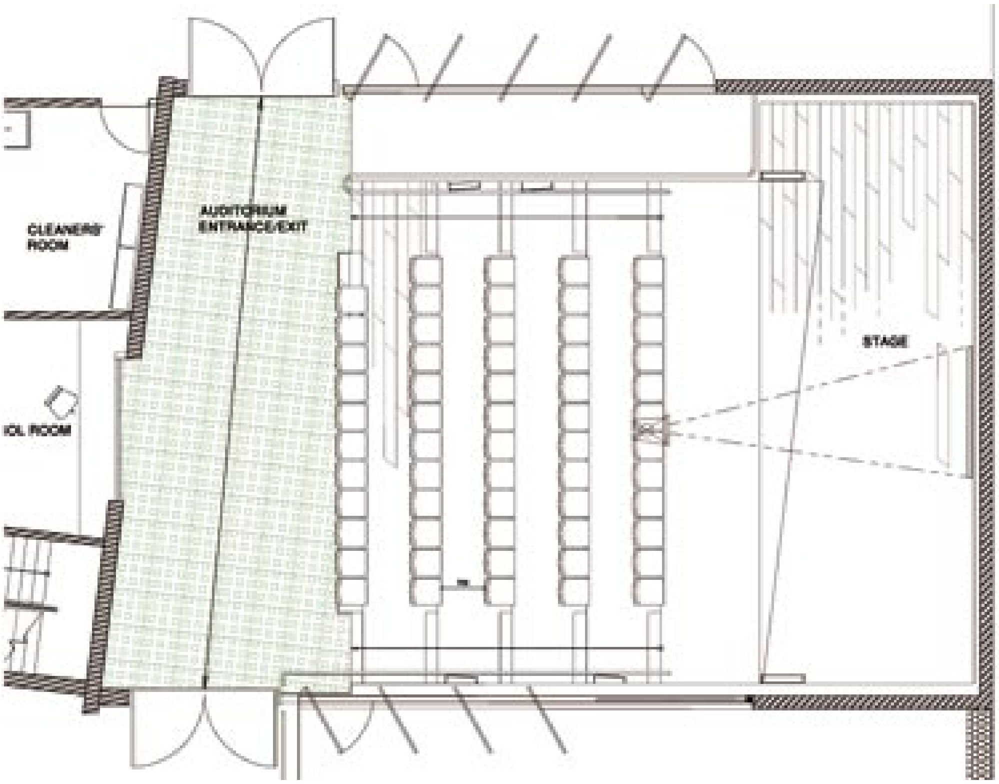
The Centre should be equipped with water-saving components for flushing toilets, taps and showers. By planting indigenous trees like the *Celtis africana* in the landscape, the long-term cost of sprinkler systems can be minimised.

5.2 Acoustics

It was vital that the acoustic performance of the auditorium be highly efficient and this requirement had a direct bearing on its interior design. The auditorium facilitates educational programmes, lectures, conferences, informal talks, other gatherings and social activities. Users may include learners, cycling and hiking clubs or corporate groups. The design used here challenges the conventional auditorium, the so-called 'black box'; instead it allows the facades to open, while ensuring that formal lectures with projectors and other high-tech equipment can be used when necessary. The shape of the auditorium and the materials used illustrate how an innovative design is able to optimise the acoustics.

Figure 81: Reflection of sound in the auditorium





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5.2.2 SHAPE

The slight deformity of the rectangular space of the auditorium is to prevent unwanted flutter echoes from forming between the parallel surfaces in the space. The back wall (next to the control room), (Figure 82) is at an angle of seven degrees to the front wall (at the back of the stage) and the curved plywood screens are rotated five degrees away from the side walls.

The shape of the interior space is between 1.2 and 2 times as long as it is wide, which is the accepted proportion for auditoria. The raked seating puts all listeners into the direct sound path of the speaker on the stage and avoids sound shadows being cast by the person sitting in front of another member of the audience. The plywood screens that curve to become reflective ceiling elements also enhance the reflection of the speaker's voice (Figure 81). They also allow viewers on the balcony to see the person who is addressing the audience from the stage.

5.2.3 MATERIALS

For good sound enhancement, the screens on the sides of the auditorium consist of 32mm plywood. This a material that reflects the high frequencies that carry information to the audience while absorbing low base sounds that generate noise. The addition of glass wool in the cavity between the two layers of plywood enhances the low frequency absorption. The sides of the auditorium have retractable pivot doors that comprised two corrugated iron sheets with medium density fibreglass between them, resulting in the following properties:

- the corrugations of the metal reflect a well-spread diffuse sound
- the fibreglass absorbs unwanted low frequency sounds

The concrete back and front walls are clad with 40mm thick, 40 kg/m^3 Fibretone (perforated vinyl facing) sheets to absorb sound at all frequencies and avoid the sound in the auditorium from reaching the offices.

The flooring of the auditorium is commercial grade 8mm treated bamboo planks on a particleboard substrate. At the entrance (Figure 82), however, a non-slip, durable floor material is needed as this area is exposed to heavy pedestrian traffic as well as sun radiation and moisture in rainy weather.

Absorption Co-efficients: room: 13.4 x 9.6 x 4.8

Frequency	(Hz)	250	500	1k	2k
Floor:		0.16	0.28	0.3	0.28
Walls (Fibretone):		0.24	0.66	1.12	1
Walls (Plywood):		0.25	0.15	0.09	0.05
Ceiling (Acoustone):		0.2	0.3	0.44	0.55
Ceiling (Plywood):		0.25	0.15	0.09	0.05
Doors:		0.06	0.06	0.06	0.06
Windows:		0.25	0.18	0.12	0.07
Seats occupied 90% (per seat)		0.32	0.38	0.35	0.38
Air (per m³)		0.001	0.003	0.006	0.011

Absorption	(m²)	250	500	1k	2k
Floor:	130	20.8	36.4	39	36.4
Walls (Fibretone):	25	6	16.5	28	25
Walls (Plywood):	42.5	10.625	6.375	3.825	2.125
Ceiling (Acoustone):	105	21	31.5	46.2	57.75
Ceiling (Plywood):	23	5.75	3.45	2.07	1.15
Doors:	42.5		2.55		
Windows:	20		3.6		
Seats occupied	72 people		30.4		
Air	650 m³		1.95		
Total Absorption in room (A)			135.7		

Room total surface (S)	388m²
Average absorption Co-efficient (α) (1)	0.4
Reverberation time (T60) (2)	0.6

1 $$\alpha = \frac{A}{S}$$

2. $$T60 = \frac{0.161V}{-2.3\, S \log(1 - \alpha)}$$

V = Volume of room (m³)
S = Total surface area (m²)
α = Average absorption coefficient

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Heavy-duty commercial carpet tiles and safety PVC flooring is specified for this area. Thick absorbent carpet flooring dampens the sound of footsteps and this is important as people tend to filter into the auditorium after a lecture has commenced. The chair surfaces are of a spongy material to ensure a constant level of sound absorption whether the auditorium is full or empty, thus limiting the effect on sound quality.

5.2.4 REVERBERATION TIME

To determine how well a space performs acoustically, the reverberation time (the time for sound to travel from speaker to audience) is calculated (Figure 83):

Figure 82: Floor materials in the auditorium

Figure 83: Calculation of the reverberation time in the auditorium

Room: 13.4m x 9.6m x 4.8m

Floor: 150mm concrete floor with 20mm particleboard underlay on steel joints at 600 c/c spacing with 190mm bamboo flooring planks. Average air gap of 80mm with 50mm glass wool.

Ceiling: 82% 15mm Acoustone on T-hangers with 500mm air space and 50mm glass wool. 17% 20mm laminated plywood, 100mm average air gap with 50mm glass wool.

Walls: 25mm Fibretone against concrete and 20mm laminated plywood, 100mm average air gap with 50mm glass wool.

Doors: Steel frame pivoting doors with galvanised sheeting, 50mm air gap with glass wool and seal.

Windows: 4mm glazing

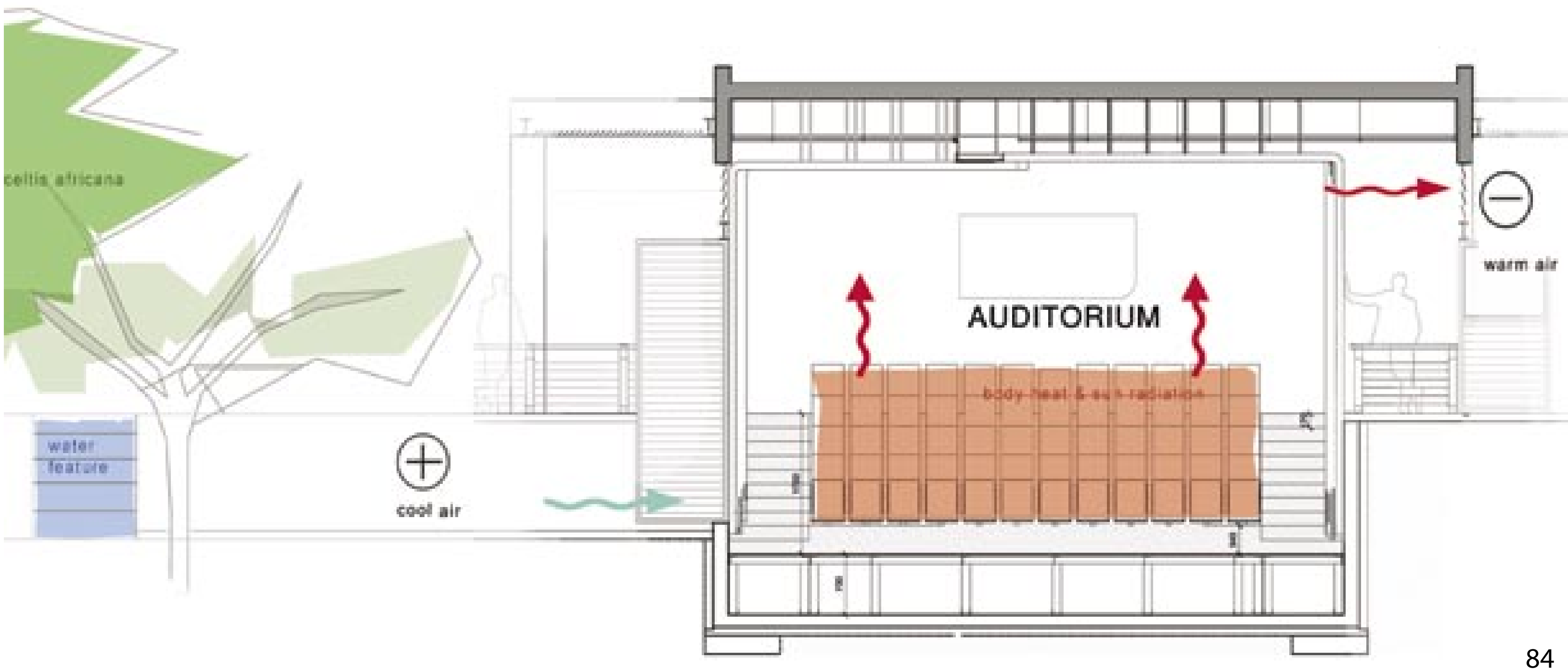
The accepted reverberation time for speech purposes is one second or less; a musical performance requires a longer reverberation time. By scrutinising the calculations (Figure 83) it can be seen that the calculated reverberation time is 0.6 seconds with the suggested materials. The amount of absorption in the auditorium is thus estimated to be sufficient. To optimise speech intelligibility, however, care should be taken that there are always doors open; an open door aids absorption in a space.

References for this section

1. J.P. Nel, Unpublished notes compiled for Earth Sciences 210, 2002, UP Department of Architecture: 'Acoustic Notes and Thermal Performance of Buildings.'
2. Personal interview, J.P. Nel. Mechanical Engineer, 10 August 2006.

5.3 Ventilation

Although the Centre is ventilated by means of passive ventilation methods, sufficient ceiling space forms part of the design, making it possible to install additional HVAC (heating, ventilation and air-conditioning) systems. By including the additional HVAC systems into the design consideration, the building can readily adapt to any changes made to the interiors and this will ensure the thermal comfort of the users over the lifespan of the Centre.



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5.3.1 NATURAL VENTILATION

Natural ventilation is only efficient if proper cross-ventilation can occur; both the path and the distance of airflow influence cross ventilation. Throughout the Centre, the depth of the spaces has been kept to a minimum (an average depth of 7 metres) to create opportunity for cross-ventilation to occur.

5.3.2 AUDITORIUM

The principles of passive ventilation that have been applied in the auditorium attempt to take advantage of Pretoria's climate that is seldom extreme. The interiors can open out to the landscape and allow visitors to enjoy the scenery while they are in the comfort of a building.

The prevailing winds in the Pretoria area are south-easterly, therefore the auditorium is oriented parallel to the windward direction. This allows for effective passive ventilation of the auditorium. Air moves over the water feature and cools off further as it moves through the shade of the *Celtis africana* trees planted on the eastern side of the auditorium. The cool air creates a positive pressure on the eastern side of the auditorium. Warm air generated in the auditorium from body heat (and the small amount of solar radiation that penetrates the facade) cause negatively charged air in the ceiling (warm air rises) of the auditorium. The difference in charged air causes effective passive ventilation of the auditorium. The grills in the eastern wall (Figure 84) allow cool air into the auditorium from beneath the seating structure. The warm air rises due to this change in charge (warm air negative, cold air positive) and then exits through the glass louvres at the top of the western facade.

References for this section

1. J.P. Nel, Unpublished notes compiled for Earth Sciences 210, 2002, UP Department of Architecture: 'Acoustic Notes and Thermal Performance of Buildings.'

Figure 84: Passive ventilation of the auditorium

5.4 Lighting

Although the Centre will be used for the most part during the day when minimal artificial lighting is required, there will be private functions and exhibitions held in the evenings, especially over weekends. For artificial lighting in the Centre low voltage dichroic halogen lamps, tungsten halogen lamps, LED lamps and fluorescent lamps are used.

Clustered LED lamps are use in the general signage of the Centre and in the auditorium. The advantages of LED lamps are that they can be grouped, produce a diffuse light, generate very little heat and have a life span of 100 000 hours. LED lamps are expensive however, but initial high cost is outweighed by the energy costs saved over the building's life span.

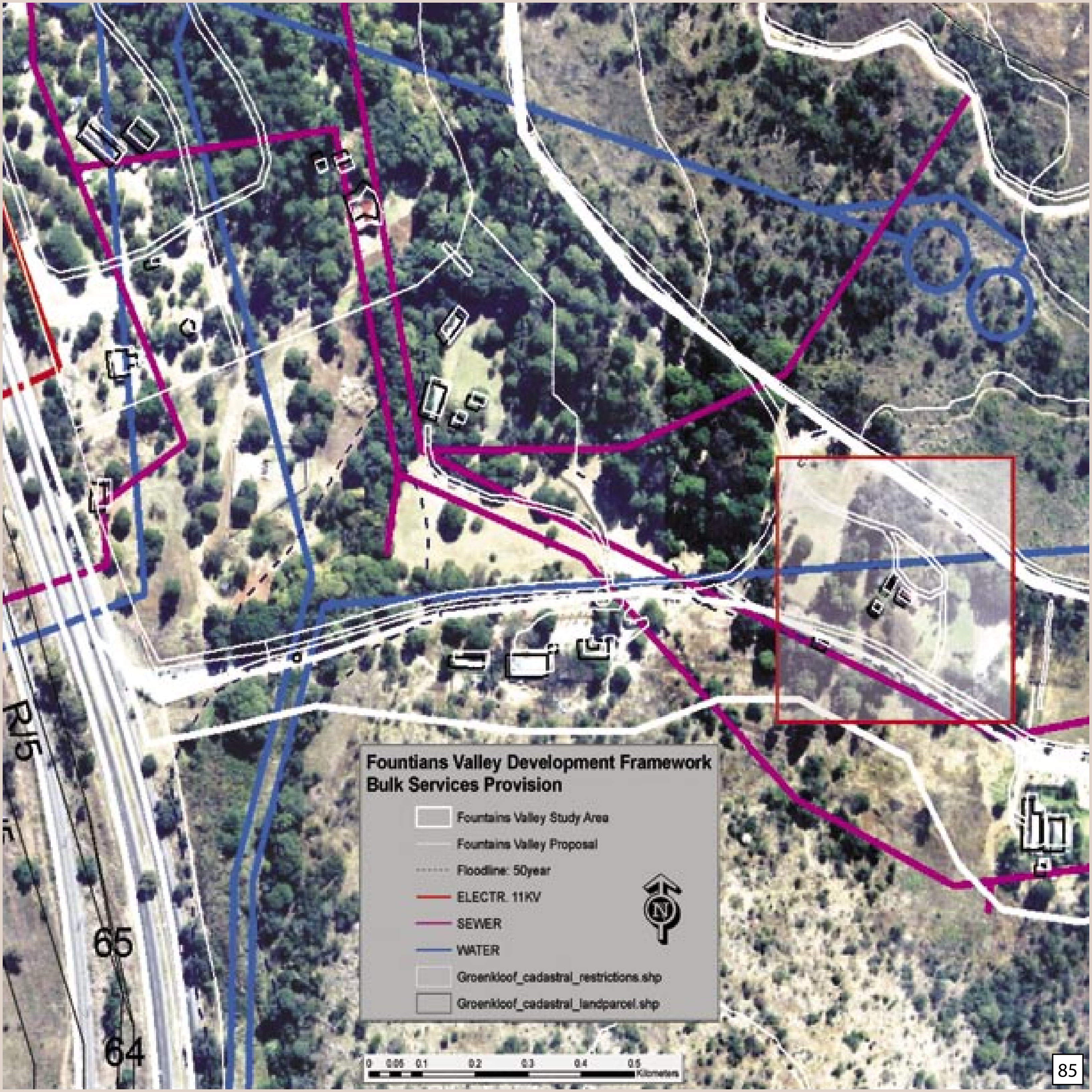
Phillips batten Fluorescent lamps are specified in the auditorium and exhibition area. Fluorescent lamps have a long lifespan, although less than LED lamps. Fluorescent batten lamps are used to illuminate the auditorium screens (Figure 59, 60) as they are simple to mount, easy to replace and supply a continuous diffuse beam of light.

Low voltage and tungsten halogen lamps are specified for the exhibition area as these lamps give a space good quality light and colour rendering. Low volt (12V) tungsten halogen lamps with dichromatic reflectors give a cool beam and have a 2000-4000hour life span. Halogen lamps are not as energy efficient as fluorescent and LED light, yet the quality of the visitors' experience justifies this more expensive choice.

5.5 Fire protection

The Groenkloof Nature Reserve is protected by the National Parks of South Africa and contains valuable wildlife and exotic plant species. Management has a required system in place to monitor the reserve and to react swiftly if fire should break out.

Preventative measures and fire equipment should, however, be included in the design of the Inter*active* Centre. Two sets of fire hose reels and portable fire extinguishers are provided at strategic points in the Centre and are visible to visitors by means of signage. The portable fire extinguishers are the



Fountians Valley Development Framework
Bulk Services Provision
Fountains Valley Study Area
Fountains Valley Proposal
Floodline: 50year
ELECTR. 11KV
SEWER
WATER
Groenkloof_cadastral_restrictions.shp
Groenkloof_cadastral_landparcel.shp
0 0.05 0.1 0.2 0.3 0.4 0.5 Kilometers
R/5
65
64

4.5kg carbon dioxide-type and the fire hose reels have to comply with SABS 543. A sprinkler system is to be installed in the auditorium as a preventative measure, as the interior finishes of the auditorium contains natural materials such as plywood and bamboo planks. All materials in the Centre are to have a minimum fire stability of one hour.

5.4 Water and sewage

A main water supply runs through the site on which the Centre is to be constructed (Figure 85). The shower units and all taps in the Centre are to be connected to this system.

According to Adriaan Kurtz, manager of the department of water and sewage at the City of Tshwane Metro Municipality, '… a main sewer runs through the Fountain Valley and is in the process of being upgraded. All planned sewer lines must be linked to this existing sewer system.' Based on this fact and the water and sewage plan supplied by the City of Tshwane Metro Municipality (Figure 85), the sub-stacks of new water closets will be connected to the main sewer that runs through the site (C: Design drawing no. 2).

By making use of the existing water and sewer lines as far as possible, the impact on the environment is kept to a minimum, ensuring that the Inter*active* Centre is a sustainable development.

Figure 85: Aerial photo from the Tshwane Metro Municipality with the sewage, water and electrical layout indicated in the Fountains Valley. The site of the Inter*active* Centre is highlighted