THE USE OF WATER AND HYDAULICS IN THE LANDSCAPE DESIGN OF SIGIRIYA

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2003 October

This is to declare that
this dissertation presented to
the University of Moratuwa.
for the master of science in lansdcape design
has been written by me.

UOM Verified Signature

....
Susira Senadhi Udalamatta; 2003 June

To

Present Nature lovers

and

ancient master builders

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ABSTRACT

"The concept of landscape design begins with emerging and developing societies based on agricultural productivity and a symbolic approach to the universe." [1]

"The design principles and urban environments were created and reflected both the relationship of society and political impacts". [2]

A Sri Lankan civilization flourishing for more than two thousand five hundred years has made many out standing contributions to art, landscape architecture and technology.

In ancient city planning and urban landscape design of Sri Lanka it is possible to identify planning principles and concepts which integrate manmade and natural elements. The Archaeological remains of different periods in its history reflect these Sri Lankan concepts and principles of landscape design.

When selecting a site for a city, in addition to being a strategic point for protection and safety its topography, aesthetics and availability were also carefully considered. The fortified garden city of Sigiriya is considered as a classic example of identifying landscape design concepts with Sri Lankan traditions of hydraulic engineering.

A description of Sigiriya's landscape design concept has been appropriately summarized in verse by a contemporary poet.

"When Sigiriya on its base and crest,
Bore noble works of man
And clinging to its scraped breast
The guarded galleries ran" [3]

Built on the summit and surrounding slopes of the Sigiriya rock, this fortress city is an accepted master piece of ancient landscape architecture, construction technology and hydrology.

This dissertation attempts to focus on selected aspects of the Sri Lankan uses of water in landscape design, based on the development of hydraulic technology, during the Anuradapura period, and as applied at Sigiriya.

The first chapter summarizes the historical background of Sigiriya. The development of Sri Lankan hydraulic technology and water uses in Anuradapura period is outlined in the second chapter. The design concept, principles and water uses of landscape are detailed in the third chapter. Hydraulic details within and around the Sigiriya citadel are dealt with in the fourth chapter. The fifth chapter ends the dissertation with a concluding discussion and suggestions.

1. Jung C.G. The Spirit in man Art & Litreture : London – 1966
2. Jellicoe, Susan & Geoffery : The Landscape of Man: London – 1975
3. S. Paranavithana. Sigiri Graffity : Colombo.

INTRODUCTION

“Sri lanka is an Island well known as a paradise because of its evergreen beauty with its water source enchanting mountains and variation found in climate. Geographical situation of the island is the main generative force for the climate variation.”[1]

The land area of Sri Lanka covers about 6.56 million hectares of which 1.8 percent includes inland waters. Hence ancient civilization was mainly settled by a water- based society. As given in the legendary story of its settlement the island was inhabited by four original tribes, the Yakka, the Raksa, the Naga and the Deva. These early people gradually developed systems of sedentary agriculture.

“The science relating to the flow of water and gravity flow irrigation gradually developed with the cultivation of the soil. Rain water was collected in water storage tanks and it irrigated their fields during the dry period of the year. It is believed that at the arrival of Vijaya. (A prince from north India in the 6^{th} century BC) small scale irrigated hydraulics systems were already in operation”2

> “The settlement process, the manmade environment and the landscape were dominated by the wewa or a large storage tank and the paddy fields. The organization of small tanks into a linear cascading sequence within micro-catchments, allowed greater efficiency in the use of water. ”

Water is the blood of the body of Sri Lankan society. The spatiality of water of Sri Lankan society can be summarized by poems.

Wisdom of water, voyages in samsara
Hemmed by suffering, thirsting for knowledge
Seek refuge in you.
Sturdy rural farmer, with the new born baby
In thanks giving faith, pour milk and jasmine water.

Breeze moistened by ripples, of Tissa wewa,whispering
Prayer rustles the emeralled leaves, shimmering in golden
0sunrays
Like myriad fans to calm, the body and mind of votaries.[11]

G.H.A. Suraweera.

Water is used subtly in the fields of art and landscape to enhance esthetic qualities of the environment. With the qualities of water expressed by the techniques of irrigation and water management. The ancient Sinhalese engineers & architects, practiced their skills on behalf of their society, and as its power grew so did their boldness & willingness to experiment.

1.Daily news, 2003.05.08, ANCL publishers

Background reference

A commentary on the hydraulics of Sigiriya becomes more meaningful when the subject is prefaced with an appreciation of the prevailing state of the art of hydraulic engineering, during the period of its construction and of the agricultural knowledge of the past that catalyzed and influenced the development of this technology.

This heritage imparted a tradition of water conservation by means of effective resource management and an attitude that could best be expressed through the famous dictum ascribed in the **Chulavamsa** to king Parakramabahu the Great (AD 1153-1186).

"Truly in such country not even a little water that comes from the rain must flow in to the ocean without being made useful to man…."[2]

1. Chulavamsa ch 68 / 11,12
2. Brohier R.L. Ancient Irrigation Works In Ceylon 1934 Part i

Other monarchs of this land were probably less articulate, yet the same philosophy of water conservation was practiced by them and passed on, from very early times.

R.L Brohier in a commentary on the ancient Irrigation works in Ceylon describes the ancient agricultural picture, as follows.

"….Should choice or compelling circumstances take you to the low-country dry zone in the North of Ceylon you will find for miles around, striking evidence extent of paddy cultivation and the colossal nature of the system of artificial irrigation….."[3]

The Chulawamsa chronicle presents this same picture in statistical terms. It credits the Paracramabahu period with the construction of 534 water canals and the restoration of 3300irrigation works, clearly suggesting the scale and magnitude of the ancient irrigation system

John Still, in the book, **Jungle Tides**, provides a simple description of the overall ancient irrigation design concept.

"….Below each great tank and canal was hundreds of little tanks, each the nucleus of a village: all in the long run fed from the wet mountain zone …."1

The arid plains of the country were thus undoubtedly transformed by this system of irrigation in to fertile fields, resulting in economic stability. There fore the water resource became the most treasured commodity of early Sri

Lankan civilization, a fact vividly apparent in the familiar Dathusena legend, documented by the Chulavamsa Chronicle. The record describes the incident that occurred when the Prince Kasyapa confronted King Dathusena with a demand for the treasures of the state. Faced with an ultimatum of death, the Monarch could truthfully show nothing more than the Kalawewa reservoir as the entire wealth of his prosperous kingdom.

Royal patronage and state encouragement fostered the development of the Science of irrigation engineering in the country. By the time of the development of Sigiriya in the 5th century A.D. hydraulic engineering had developed the practice of diverting perennial water ways in to excavated anicuts that led the water into massive impounding reservoirs. A unique technology in ancient irrigation had thus been perfected. Henry Parker's writing on the earliest irrigation works in this country clearly reveals his admiration for the engineering logic and the technical skill that produced the ancient irrigation schemes. A common feature noted in all these great hydraulic works was the application of appropriate technology to suit individual situations. The analytical approach to design may be considered as the ultimate sophistication that reflects the true level of advancement in the field of ancient hydraulic engineering.

Brohier has authoritatively concluded that none of the ancient irrigation schemes of the country would have a materialized, if not for the knowledge of the highly advanced system of land surveying. He comments that:

"Channels were traced miles upon miles on gradients that would call in to use the most precise instruments of the modern age".[1]

This statement was probably promoted by the observation that ancient channels had average a gradient of as little as 6 to 12 inches of fall within a mile. The fact becomes even more impressive when it is noted that the ancient Elehera channel extend a total length of fifty four miles from source of destination. The basis for such precise calculation is yet unknown. How ever the capability to conceive and construct channels of that nature is adequate proof of the advanced engineering skills of the period.

The accuracy of this ancient hydraulic engineering science has been further demonstrated by a recent discovery. When work commenced on the Maduru oya irrigation project in 1984, and the proposed dam was set out at the site, its location was found to coincide with almost the exact position of a breached ancient irrigation scheme that straddled across the Maduru Oya. Modern engineers aided by advanced computers had unknowingly matched the engineering logic of their predecessor.

1. Brohier R.L. Ancient Irrigation Works In Ceylon 1934

Archaeological specimens from this ancient dam site were carbon dated and analyzed to establish its antiquity. The result have dated the structure as belonging to the 4th century A.D, and assigned its construction to the time of king Datusena's reign. Assuming this time scale in history, the Sigiriya era which commenced immediately after Datusena's rule, must have there for inherited all of these technical advances. The engineering success of the ancient Maduru Oya irrigation scheme may well have been due to the designers of Sigiriya and their confidence to experiment with hydraulics in an unprecented manner.

Centuries of practical application had perfected a hydraulic technology with excellent qualities of workmanship. This ancient product may be judged from the performance specification s described in the Chulavamsa.

"In which the joints were scarcely to be seen very firm,queit,massive, like to a solid rock and provided with a complete coating of stucco"[1]

The designers of Sigiriya showed themselves a match for the skill.

1. Chulavamsa Ch 68 / 26, 27

THE STUDY

This study **The use of water and hydraulics in the landscape design of Sigiriya** is an attempt to focus attention on a few aspects of this ancient skills that operated the water system within and around the Sigiriya citadel.

METHODOLOGY

The methodology adopted to achieve the aforesaid purposes was the analysis of research material collected by various field surveys, historical documents, and contemporary researches.

METHOD OF ANALYSIS

The analysis was carried out with reference to these aspects.
They are,

1. Analysis of development of the hydraulic technology in the Anuradhapura period.
2. Analysis of hydraulic technology in Sigiriya.
3. Technical analysis of major hydraulic devices channels, sluice, weirs, fountains, notches.

PROBLEM ENCOUNTERED

Information about ancient hydraulic technology in Sri Lanka is scanty. One of the major reasons for this deficiency is the lack of research in the fields of landscape and hydraulics. This deficiency was the major driving force which encouraged this study, but the same stood as the major problem when collecting the research materials.

The most serious problem encountered during the field survey was difficulty in the identification of underground water lines often destroyed by the unskilled laborers, during the conservation period.

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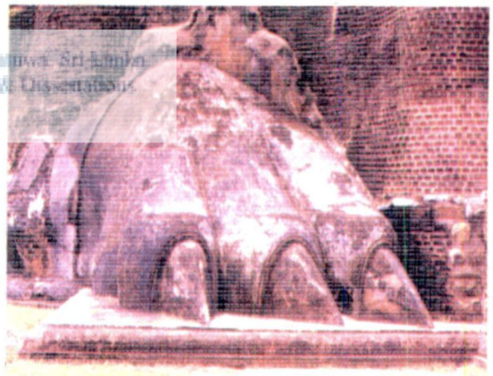

Chapter One

1. TOPOGRAPHICAL AND HISTORICAL STUDY OF SIGIRIYA REGION

The role of historical and topographical study in illustrating design principles, and technology helps us to understand our own style and heritage. The gardens and ancient cities which were created in Sri Lanka, reflect both the relation ship of society to Nature and the structure of society itself. The role of plants and the design concepts of the gardens in these ancient cities, and the surrounding agricultural methods and hydraulic technologies vary according to the climate, topography, social and political background of the country. The concepts of .landscape design and technologies are moderated by climate and geographical location.

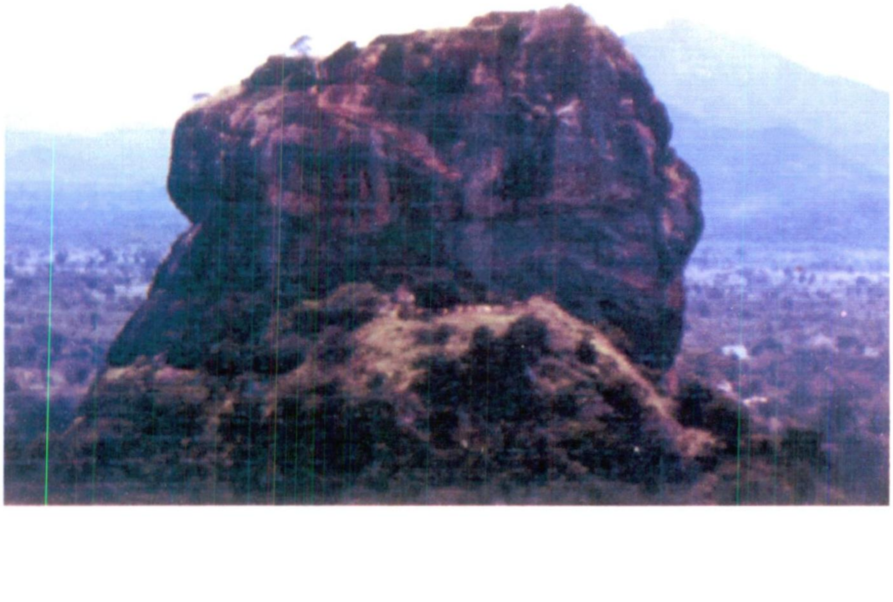

Fig. 1.1 Geological formation of Sigiriya region
Source. SLT Calendar

1.1 TOPOGRAPHICAL AND GEOLOGICAL STUDY

"Sri Lanka is one of the most beautiful islands in the world. The reason for this is clear, in its magnificent geological features-that is, wide plains and high mountains, gentle slopes and steep precipices, wide sandy beaches, green forest hills in combinations that are particularly delightful to the eye and satisfying to the aesthetic sense of the natural landscape".[1] All these geological features are recognized and describe the three well –marked peneplains. A peneplain is defined as being "almost a plain", produced by long periods of weathering and erosion.

The lowest peneplain stretches from cost to coast in the north of Sri Lanka. Anuradhapura is the first agricultural civilized and developed city of this plain. . But its annual rainfall is very low and the dry season extends through out the year. Water management and hydraulic technologies were rapidly developed here due to the geological formation of the peneplane.

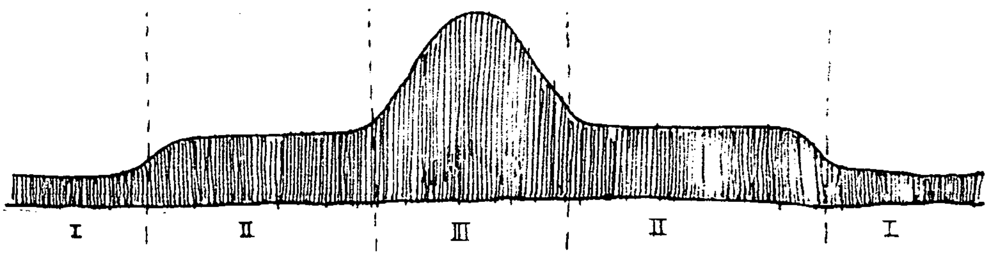

Fig 1.2 Diagramatic section across Sri Lanka,showing the three peneplains (D.N Wadia 1942.)

The geology of Sri Lanka.A.C. Cooray.1967p4

Topographically, Sigiriya is a part of the northern pen plain of Sri Lanka. In the formation and origin of this peneplane, Adams comments that this area forms a part of the lowest of the three peneplains of Sri Lanka. According to Erbs'(1970) submission ,this region comes under the two sub-geomorphologic units of the "Alahara", ridges and the south eastern part of the Anuradhapura peneplain. Erb makes this identification on the ground of weathering. The distinctive rock-outcrops or inselburgs visible in this region are well represented at Sigiriya, Dambulla, Pidurangala, Ritigala, Mapagala and Endaragala. The steepness of the sides of the erosion remnants of the Sigiriya rock provides commanding views over the surrounding landscape.

Sigiriya is located in lat: 7.59North and lon: 81 Eastern dry zone of Sri Lanka. According to its modern administration boundary, it belongs to the Matale District in the Central Province, which includes the three major heritage city centers of Anuradhapura, Polonnaruwa and Kandy. Sigiriya was named as Sri Lanka's 3rd world heritage by UNESCO.

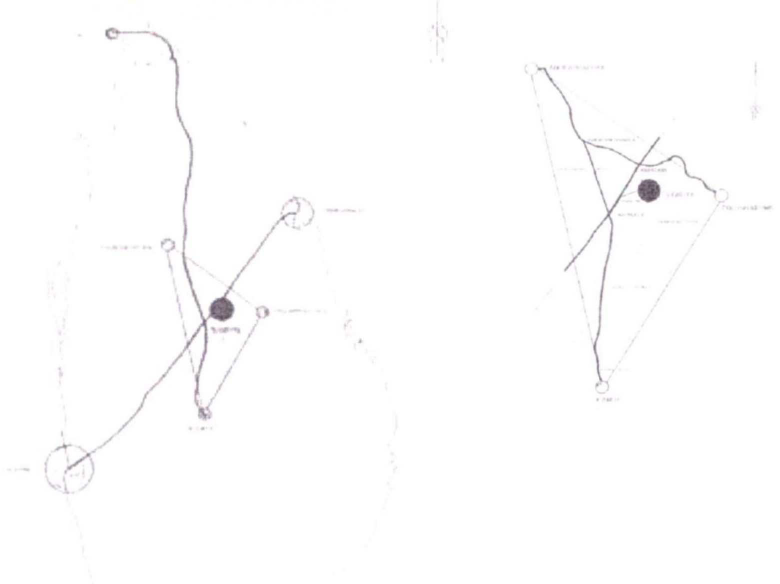

Fig. 1.3 Location of Sigiriya Source. Sigirya guide map 1992

Fig. 1.4 Topographical formation of Pidurangala & Sigirya looking eastward

The flat terrain, in front of the lions' paw platform was used in part to design the water garden. On the summit of the rock the palace complex was built on a series of brick terraces stepping down towards the south.

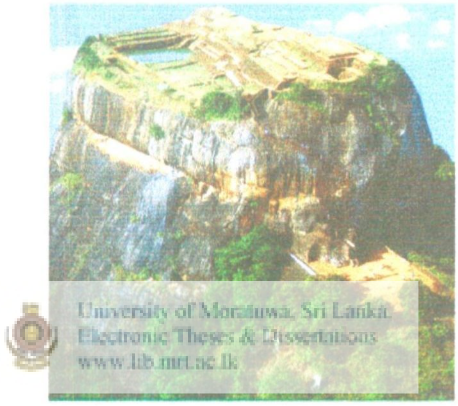

Fig 1.5 The flat terrain, in front of the lion paw.

- **Geology**

The geology of the Sigiriya region is made up of the same types of rock that forms the Polonnaruwa region. These rock types fall in to the highland series and have their origin in the pre –Cambrian period. That is, they have the longest geological history of all the rock forms of the Sri Lanka.

The common rock- types found in the area are magnetite, gneiss, quartzite/quartz and crystalline limestone. These rocks and minerals have been used to design Sigiriya garden, and the king's palace as demonstrated by its archaeological remains.

Topographical form and design

"The Sigiriya rock it self has a distinctive shape of a lion seen from a particular angle. This might have been the reason for it being named Sinhagiri".

The only remaining evidence of the manmade brick and plaster lion built at Sigiriya by Kassapa, are the paws surviving at the foot of the north face of the rock.

1.2 SOCIAL AND THE POLITICAL HISTORY.

"Sigiri, known in ancient time as Sinhagiri, is situated in the north central part of Sri Lanka. It rises a height a bout 200m from the surrounding plain. In the 5th century A.C this rock became the abode of king Kasyapa (477-495AC), the elder son of king Dhatusena"[1]. Sri Lankan agricultural and hydraulic society reached its highest level during the Datusena period centred on the then capital Anuradhapura.

The history of Sigiriya extends back to the prehistoric period but its recent history begins in the 3rd century B.C. ,with the establishment of a Buddhist monastic settlement. By the Kasyapan period (477-495 AD) the Hinduism and Mahayana Buddhism had penetrated to society. The concept of king ship expressed in a god king is reflected in their religious teachings, according to the Prof Senerath Paranawithana.

"Sigiriya could have been a replica of mount Kailasa in the Himalayas –the legendary abode of the god of wealth,Kuvera, in Hindu literature. The Indian poet and dramatist Kalidasa, whose description of the city of the demon king in his poem"Meghaduta".[2] reflects this possibility.

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[1]. W.Geiger, Chulawamsa translation 1973 part 1p38.

[2]. S.Paranavithana, The story of Sigiriya P. 4

Political history

Kassapa believed to have killed his father, king Dhatusena killed by walling him up alive. This was caused pretext that his father would over look him and appoint prince Moggallana as heir to the throne. Kassapa' s mother was of unequal birth, while Moggallana's mother was of Royal descent and was legal consort of king Dhatusena. After gettiing his father murdered, Kassapa tried unsuccessfully to get Moggallana's consent. Moggallana went into exile and eventually returned and overthrew Kassapa.

Kassapa moved the capital from Anuradhapura and found physical security at the top of the rock Sigiri and mental contemplation in his pleasure garden which made extensive use of water. The garden was created during the period 477 to 495 AD.

"During post Kasyapan phase, after 495 AD Sigiriya was turned back in to Buddhist monastery under Mahanama*1 thero and gradually it fell into disrepair and was abandoned.

1.3 MYTHICAL INTERPRETATION OF WATER IN THE DESIGN OF SIGIRIYA

“The intimate relationship of water with the traditional society of the dry zone had given rise to the emergence of symbols as well as beliefs. Some of those beliefs had been developed into rituals influenced by foreign practices. In the 5th century A.C. some beliefs were expressed in the representation of mythical water courses and natural symbols. Water and agriculture became linked in worship, and kingship became associated with the gods. ‘Devanampiyatissa’, and king ‘Mahasen’ called ‘God of Minneriya’ reflected these emphases.

The regicide Kassapa also aspired to being a god king, in the image of Kuvera, god of wealth and well being.

The name Kuvera(Cyrus) the founder of the Persian Empire, was symbolized by megha.(clouds) and clouds were considered the source of all prosperity in bringing rain.

The word for cloud in modern Sinhalese is vala-kula which means “cloud-Rock” or cloud mountain. This mythical concept of cloud- rock was expressed in the design of the King’s palace at Sigiriya.

However, this mythical concept is also reflected in modern hydrological theory. When the clouds are flowing and it is beginning to rain, the clouds are called “Ahas Ganga. (the river of the sky).That hydraulic theory has been used to design Sigiri Palace garden and to get water to fill the ponds. That is the concept of “Ahas Ganga”

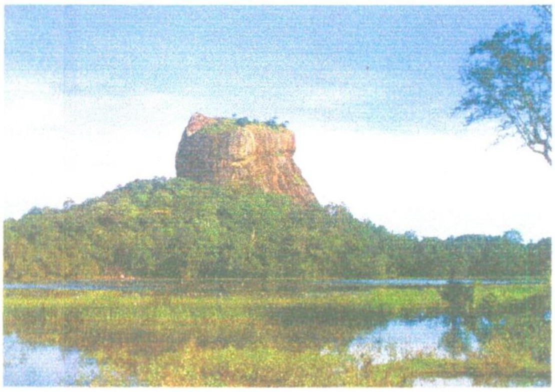


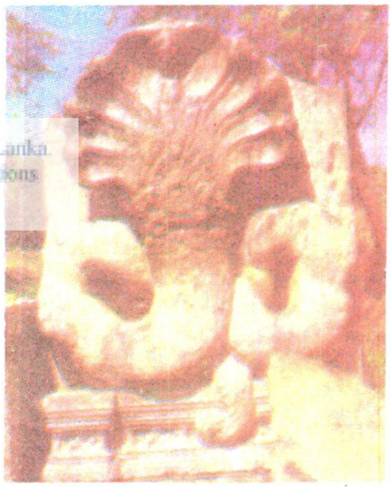
Fig 1.6 Sigiriya's skyline in profile looking north & emphasizing the Rock and Cloud design concept.

The natural setting of the rock and its surrounding boulders was used to create the boulder garden at Sigiriya. No attempt been made to change the natural topography. The rocks and the boulders have been used to create terraces descending from Sigiriya rock.

Dr. Nandadewa Wijesekara commented as follows:

" The Sigiriya complex is unique in being centered upon the massive Sigiriya rock which is a gneissic outcrop taking the distinctive shape of lion. It proves the name Sinhagiri."[2]

[2]. SLIA journal vol – 101 No. 08. P. 22



Chapter Two

2.0 THE DEVELOPMENT OF HYDRAULIC TECHNOLOGY IN ANURADHAPURA PERIOD.

Anuradhapura's development is typical of the early cities of Sri Lanka. Its success was based on the large scale cultivation of rice, and on the sophisticated irrigation techniques needed to support that cultivation. As these developed so did the city and its population.

2.1 AGRICULTURAL LANDSCAPE

The basis of the agricultural landscape of Anuradhapura were its reservoir systems and catchments, its bunded tanks and sluiced canals, distributing the collected water in a carefully regulated way under gravity. By it the Dry Zone was able to be settled and served successfully with a rice-based economy. This provided Anuradhapura's wealth.

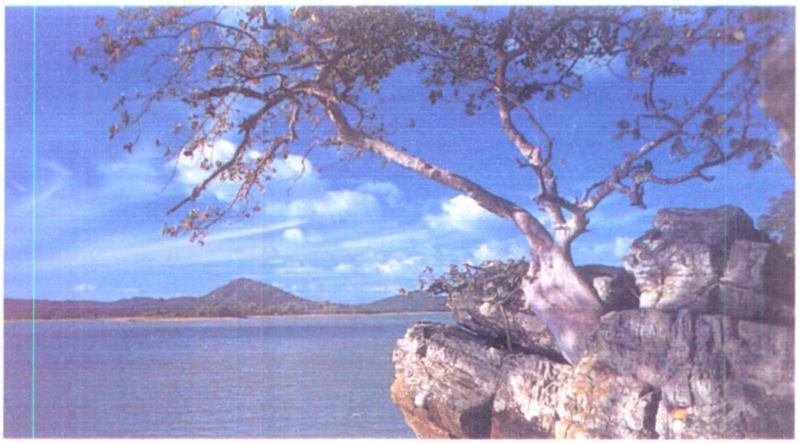


Fig 2.1 Wewa is the major agricultural landscape feature

2.1.1 Village settlements

According to ancient landscape traditions, settlement associated with water, protection and safety, was given precedence to topography and aesthetics in nature and great understanding of the surrounding environment were the key to forming rural traditional village settlements. Water is one of the most important natural elements always used in traditional city planning, village and monastic settlements in Sri Lanka. When selecting a site of settlement for a village, city or a monastery careful consideration was given to natural or artificial water masses and to the aesthetics of water in the created landscape. Due to that, mainly the fundamental buildings and even functions were sited in relation to water or constructed in water or in some cases delimited by water. Water was used in the landscape to enhance stillness, to suggest solitude, to encourage cooling breezes , to exploit sky reflection by day and by night, to create a media for water lilies, to mirror bordering buildings and mountains and finally to provide bathing and drinking. Successive Sri Lankan rulers exploited these features in the cultural aesthetic of their created landscapes.

Fig 2.2 Diagrammatic representation of the traditional village types
Source – SLIA Journal- Ashley de. Vos

There were four main types of village settlements; the tank fed, the rain fed, the hill country valley villages and the temple-dewala villages, all of them closely associated with the expression of water as a life-giving resource.

The traditional *"purana gama"*

The tank fed is the most interesting one of all. This settlement has a specific landscape layout. A large sheet of water stored in a shallow tank and an extent of paddy fields stretched below a water-retaining earth bund of the tank. Dwelling places clustered on higher ground between the tank and the forest. These were the key elements of the landscape.

Fig 2.3 Section showing a typical tank fed village settlement.
Rasika Jayasinghe, MSc dissertation, 2001

"The village was identified with the tank and the tank was mostly named in association with a tree. For example if the tank was associated with Palu trees (Manikara hexandra)it might be named Palu – gas wewa; with Divual trees (Limonia acidissima) as Divual – Gas wewa, with Kone trees (Schleichera olesosa) as Kone – gas wewa etc..... Sometimes the village was associated with a large tree and was identified by the name of that tree, Katugahmula, Muruthagahamula, Bompe, Ampe Nape etc....." [1]

[1] Landscape Tradition of Sri Lanka, Philosophy Principles and Practices, Nimal De Silva, 1996 Colombo Sri Lanka Page 5

The traditional living pattern in village settlements was zoned into its different functions according to the local geography. The land around the tank was the paddy fields "*Mudda-bima'* located below the spill level of the tank bund it ensured constant water for the paddy field even in the dry climate as well. The technology and customs in water retaining, farming, cultivating and plowing rituals in harvesting, storing and spreading practices were associated with the water potential. The *'goda-bima'* or chenas and the residential areas were located well above the highest flood level, assuring their safety even in the heavy rainy seasons.

The dwellings were located around the *'gamagoda'* or central village square, which formed the common extended living space for a community gathering of the villagers. In the center of this courtyard, were the grain stores, (Paddy and Kurakkan) the wealth of the villagers. Rituals interconnected with the well being of the villagers and their wealth were performed in this common courtyard of the village layout. The entrances were placed on the opposite sides of the public square thoroughfare through the village.

2.1.2 Impact of water on agricultural landscape

"The tanks provided a variety of fresh water fish and it was the custom to share the catch according to the ownership of land in the old field. Tanks provided water for animals. (mainly buffaloes used for draft power and dairy cattle) and for domestic purposes. Tanks also provided a variety of aquatic flowers such as the lotus and the water lily. The offerings made to temples located near the rock outcrops. The rock outcrops themselves formed the least useful elements of rural lands." [1]

The village, the temple and the tank was the dominant landscape elements in these ancient traditions. The water protecting and controlling

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structures such as the tank bund ( ) sluice gate ( ) silt trap ( ) and open channels ( ) were vital parts of the agricultural landscape. The paddy field and the area allocated for housing always followed the natural contours of the landscape, the most uncultivable or high ground being allocated for the dwellings. The colouration of the manmade features in this instance, the houses, took on that of the construction material, mud, a colour which was renewed annually. The public and royal pleasure gardens access corridors, resting places, (Ambalama)food storage buildings, (Atuwa, Kotuwa) and crop preparing areas (Kamatha) were also vital parts of the agricultural landscape. The pleasure gardens in Anuradhapura, such as Ranmasu Uyana and Sigiriya were planed and designed according to the water potential of the Tissa Wewa and Sigiriya wewa respectively.

Fig 2.4 Grain Bins in ' Gamgoda' or central village square
Source-The Architecture of an Island

2.2 WATER USE FOR SPACE MAKING

"A space may be so designed to stimulate a prescribed emotional reaction or to produce a predetermined sequence. Space may be at rest or it may induce a sense of movement, it may enclose protect and supply human needs."[1]

"Space in a large sense as in cities, countries is considered largely in terms of geometric characteristics, into which people and natural resources blend and with each water acts as the blending element."[2] Man's basic needs in a city include being able to orientate, and also to take recreation.

In Anuradapura (437 BC-950 AC) water was mainly used for two types of space making purposes: Firstly in the planned lay out of the city itself in relation to the main water catchments like Tissa Wewa and secondly in the detailed planning of particular areas like that of the Monasteries.

City Planning:-

Indian city planning practices are reflected in the first of Anuradhapura's settlements that built in 437 BC, by King Pandukabaya.

Indian building manuals give instructions for the selection and layout of a city. "Let him (the king) settle in a country". The Manasara gives directions for the planning of towns and it describes several types of towns in detail.

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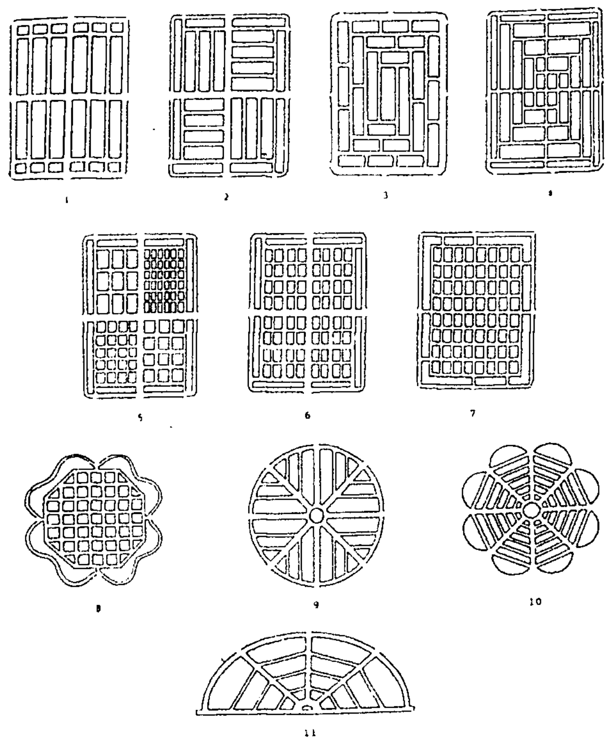
1. Nick Robinson. Design the space : Gower publishr. England 1992
2. Jhon Worize Water and culture.. Simpsion Ltd. New York 1990



1. DANDAKA
2. SWASTIKA
3. NANDYAVARTA (in Sthandila)
4. NANDYAVARTA (in Manduka)
5. PRASTARA
6. CHATURMUKHA
7. SARVATOBHADRA
8. PADMAKARA (in Sthandila)
9. NANDYAVARTA
Circular Plan. After AMANTHALWAR and RAES, Indian Architecture)
10. PADMAKA
11. KARMUKA

Fig 2.5 Ancient plan forms given in "Silpa Text"
Source- SLIA Journals

Anuradapura was built on the Nandyavarta plan, that was oriented on a water source. The city was intended to accommodate a mixed population of different social classes and religious sects. The citadel or the inner residential city was surrounded by a city wall with four gates found at the cardinal paints. The royal residences, the temple of the Sacred Tooth Relic and citizens were located within the inner city and the streets generally laid north-south and east–west. The location of the city was next to the river Kadumba Nadi or Malwatu oya. Further there are five large reservoirs and a large number of small tanks constructed for irrigation and other purposes and located around city.

On three sides, Thisa wewa, Abaya wewa, and Nuwara wewa were situated amidst parks, with the Kadumba river running through them, giving a green & cool environment throughout the year. The pleasure gardens of the Nandana vana, the Jothi vahna, and Maha vana were placed around the city.

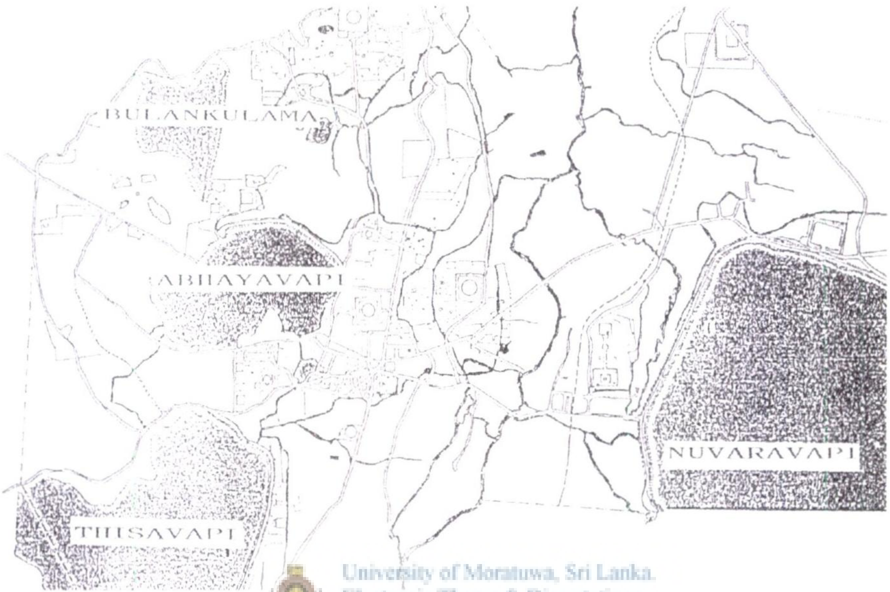


Fig 2.6 City reservoir systems of Anuradhapura
Source- Ancient Irrigation works of Ceylon

2.2.2. Planning of the monasteries

In the selection and planning of space for monasteries availability of water was of great importance guided by the "vinaya" or code of conduct. Deep water was used to create tranquility in the monastery sites. Many monastery sites were situated near a large water body and also used man made ponds. Ponds played an important role, first by storing water and thus becoming part of the landscape layout.

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w. Geiger, Mahawamsa Translation 1973 part 1

2:3 USE OF WATER FOR PLEASURE IN LANDSCAPE DESIGN

"Water is one of the most essential needs of man. Without it one could not live for more than a few days. From time immemorial man has had a close relationship with water: to survive, to create civilizations, to play with and to make works of art to express the joy of living and pleasure" [1]

Water is the main landscaping element at Sigiriya in making its gardens pleasurable. The word 'pleasure' has numerous meanings, and interpretations. Pleasure is the feeling of being happy and satisfied, or the gratification of the sense of mind. According to a psychologist's point of view, the definition of the pleasure is subjective sensation, involving positive, affective feelings. The psychologist named Herbert Spencer has explained that "Pleasures provide a mechanism for the modification of behavior and in this sense they are close to the modern concept of reinforcement of mind" [2]

1.Jellicoe, Susan & Geoffrey. The use of water in landscape design- Adam and Charles Black , London, 1971 p.14

2. The concept of reinforcement referred to the stamping of all behavioral habitats because of their satisfying consequences.

According to Buddhist philosophy, pleasure is something agreeable to one's nature or which appeals to or satisfies one's nature. This state can be applied at four basic concept levels:

1. Material or materialistic
2. Emotional
3. Intellectual
4. Spiritual

2.3.0. Landscape for pleasure

Every landscape design is expected to be beautiful or pleasing to the human mind. This should be to all five senses. Therefore desire for pleasure is always inseparably related to landscape design. Pleasure gardens, pleasure pavilions, pleasure ceremonies have existed in Sri Lanka at least since the Anuradapura period. "Those pleasure gardens and parks referred to by the terms Arama, Vihara, Upavana, Udyana and Royal pleasure garden formed an important feature of the cities of ancient Sri Lanka." [1]

1. 'Upawana Vinoda'- H.P. Harishchandra, M.D.Gunasena Ltd, Colombo 1970 (sinhala translation)

2.3.1. The royal pleasure garden – Anuradhapura- Ranmasu Uyana

The Gold Fish Park or RanmasuUyana at Anuradhapura was designedpurely to give pleasure. It was placed below the eastern bund of Thissaweva, using the Northern part of a series of linear rock out crops in the North- South direction. The basic design of Ranmasu Uyana was based on various methods of utilizing water, channeled from the Thissaweva for bathing ponds as showers, for water curtains infront of the carved rock caves, for filling ponds, for cascading, and for wetting and cooling. The creation of terraces, flight of steps, pavilions, open seats, manmade caves with painted walls, shady flowering trees, boundary walls, gateways and the overall hydraulic system contributed to the overall landscape design of the Ranmasu Uyana.

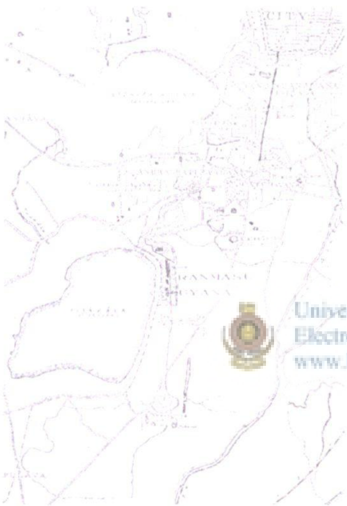


Fig 2.7 Location map of Ranmasu Uyana
Source- SLIA Journal

Ranmasu Uyana, the pleasure gardens of the kings of Anuradapura, is one of the best examples which elucidate the relationship between the living environment and the direct and indirect influences of reservoir systems and hydraulic technology on the landscape design. The development of hydraulic techniques in the Anuradhapura period can be identified by studying the hydraulics of the Ranmasu Uyana. It can be discribed as a miniature hydraulic system.

- **Ranmasu Uyana as a miniature hydraulic system**

"Facilities in Ranmasu Uyana exhibit both directly and indirectly the hydraulic systems of the built form of the dry zone living environment of Sri Lanka.

It consists of diverse water retaining structures and channels ,varying from small to large. The most important characteristics of Ranmasu Uyana are it's representation of a model reservoir system in Sri Lanka. It has a source of water supply, that is, Thisavapi, and an intricate system of channels diverting this water to various facilities.

Numbers of small cisterns are embedded in these channels to regulate flow and they functioned in the same way as the Biso-Kotuwa, the sluice, of an ancient reservoir. There several water retaining structures receive (SLIA Journal vol100-no5-Dr Samitha Manawadu) water from channels, and many temporarily retain water for usage. These retaining structures are interconnected by channels, in a similar way as that of a major reservoir system such as Nuwara Kalaviya or Thamankaduwa.

The Ranmasu Uyana was not only a reservoir system by itself but was part of the major reservoir system of Nuwara Kalaviya. It received water from Thisavapi, which was made to flow into several minor reservoirs within its site one after the other, then these waters were discharged in to Malwatu Oya again, a very important element of Nuwara Kalaviya system.

- **Hydraulics of water distribution system**

Most of the hydraulic devices such as channels ,underground conduits ,sluice gates , cistern, aqueducts, and wires are used t control the water in Ranmasu Uyana. All these devices are creatively advanced, and were expressed here solely for the purposes of display and recreation.

The out ward flow through the ancient Royal sluice of Tisawalpi was interceped at the main cistern before entering in to main channel. This cistern has facilities to control water allowing surplus to be discharged to the neighbouring area enabling it to flow in to the moat of the Northern ruins. Further, the cistern has facilities to separate silt.

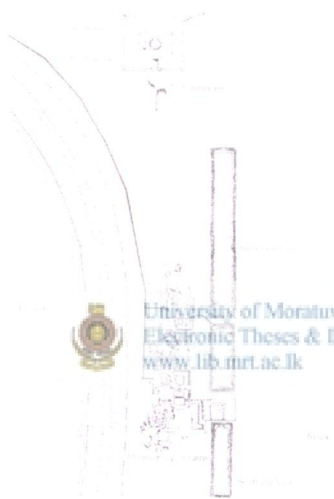


Fig 2.8 Layout plan – Ranmasu Uyana
Source- SLIA Journal

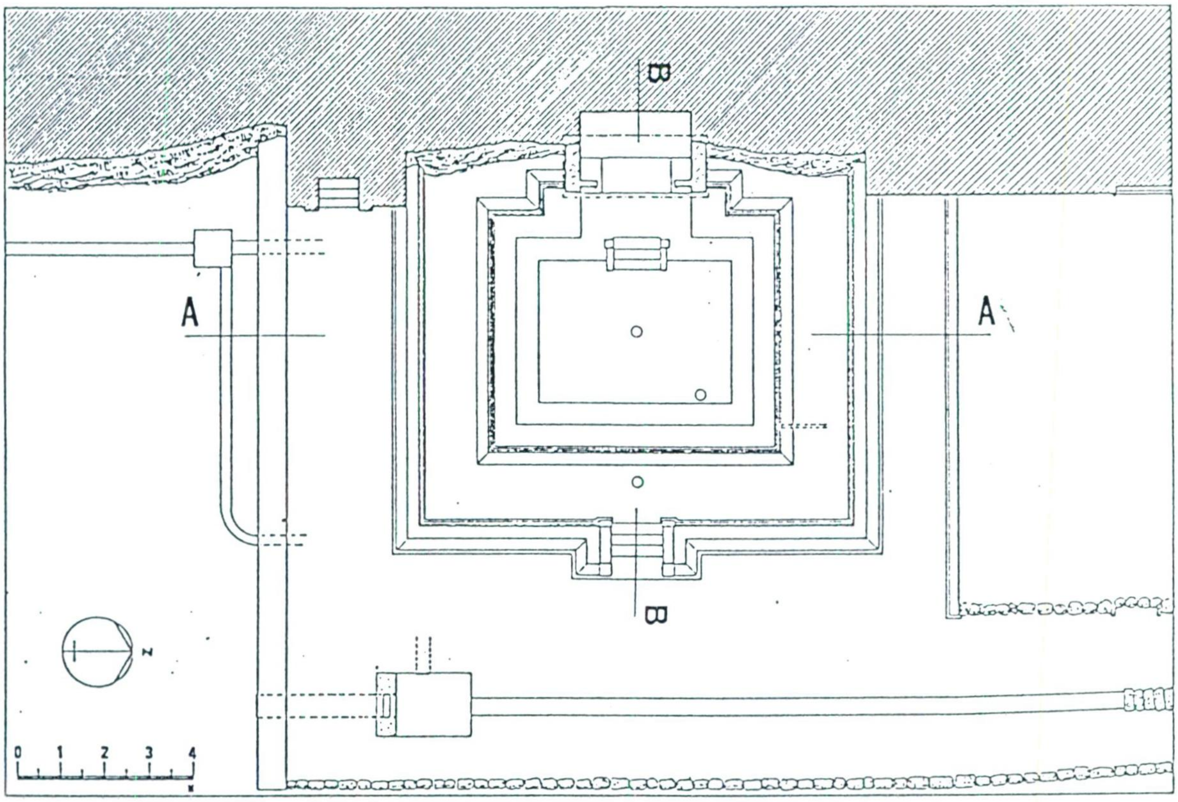
The main channel, which was flowing in a southward direction, has no cisterns to regulate its flow, the first to discharge surplus in to the lower area in the east plain. The second to divert part of the flop in to the pokuna B; and the third, the terminal of main channel, which diverts the flow in an east ward direction.

Surplus water discharged in to the lower areas was collected in a sub surface drain and directed to a meandering channel through a modified system, which has the facility to control intake. This channel, built with pebble paving in an organic snake form passes through trees and rock banks resembling a water course in its natural path before reaching another cistern, which controls its out ward flow into the surrounding landscape ,to be discharged into the long moats in an organic snake form passes through trees and rock banks resembling a water course in its natural path before reaching another cistern, which controls its out ward flow into the surrounding landscape ,to be discharged into the long moats in the eastern quarter. In the cistern, a channel from the west is add ed to this channel and this channel over passes a discharge channel from pokunaA with out disturbing the flow.

Diverted water to pokuna A was taken through a brick built surface channel which is divided into two branch channels before the water is discharged in to the surrounding landscape through channels and two cisterns. The discharge of pokuna –A,in the form of a stream flows along the rock boulder.

Fig-2.9 Details of Ranmasu Uyana – Pokuna A,B & C
Source- SLIA Journal

One of these subdivided channels is buried below the pavement. The surplus water from these two flows is collected at the peripheral paving and discharged in to the surrounding landscape through channels and two cisterns discharge of pokuna A is sent to the eastern moats through underground channels. Water diverted at the terminal of the main channel is taken along an east ward channel to a cistern,which controls its' flow and junctions as the inlet to three buried aqueducts. The surplus is allowed to flow in to the natural landscape through a brick built drain from this cistern. Three buried aqueducts carry water below the floor of the bath house before it enters the perforated pipes spanned above pokuna.B.too which served also as awas a shower bath house. The rest of the water, directly flows in to pokuna C,while surplus from pokuna B was also



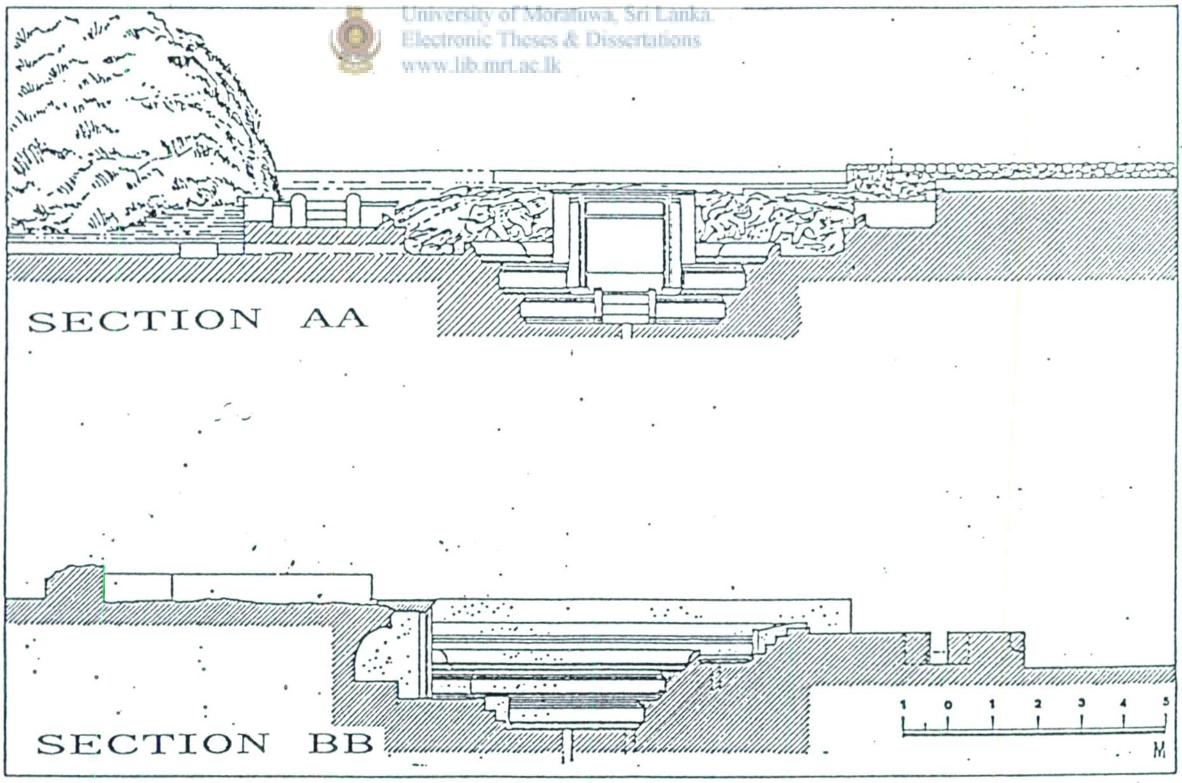


FIGURE:
DETAILS OF POKUNA A

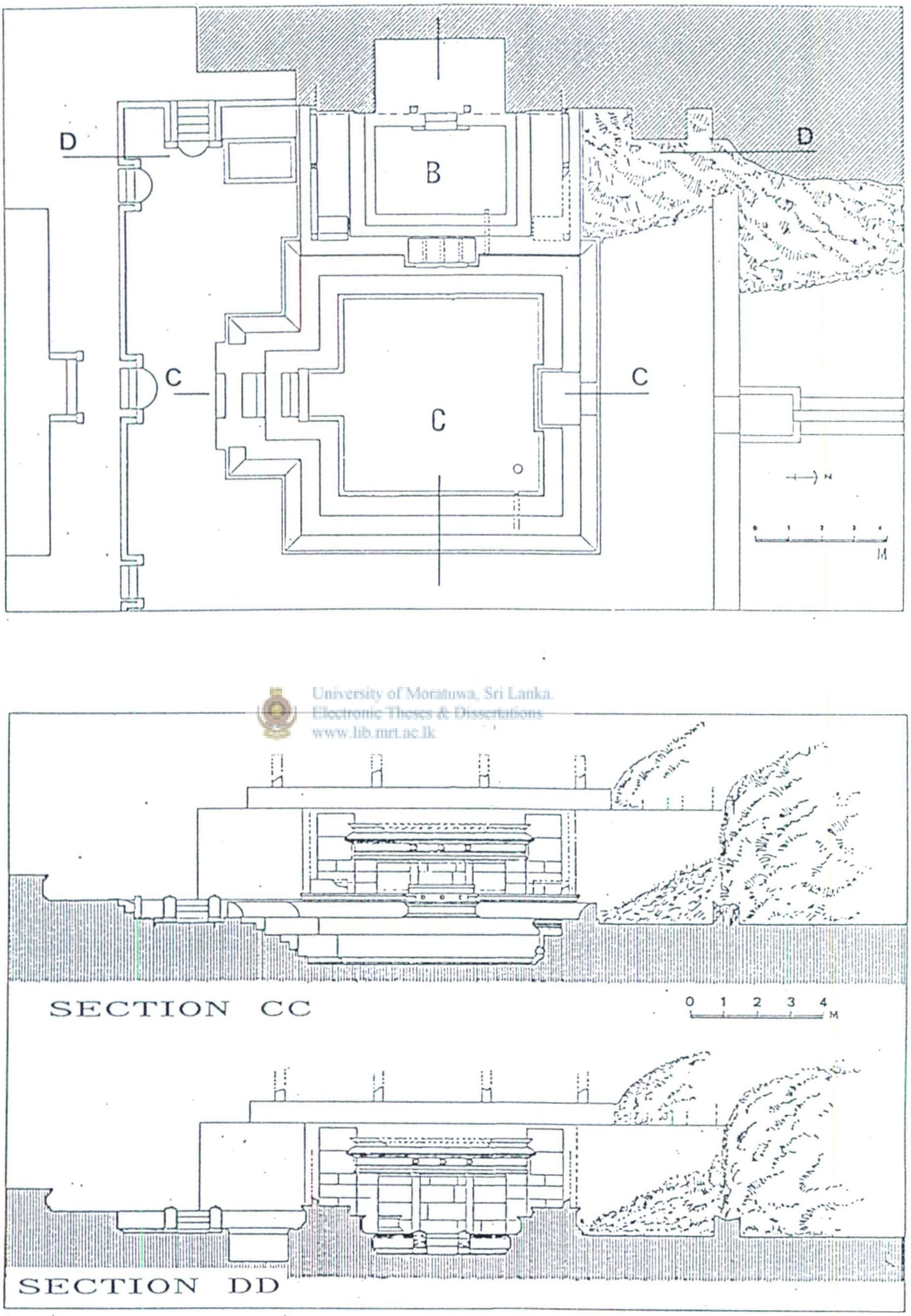


FIGURE:
DETAILS OF POKUNA B AND C

allowed to flow in there. Discharge from pokuna Cis taken through a buried aqueduct to long moats in the eastern quarter.

Surface drainage of the area between pokuna A and the twin ponds Band C is collected in a brick built channel which flow from the center to two ends. South ward flow is regulated at a cistern from which, a part is allowedto flow in to pokuna,C while the surplus is diverted to the natural landscape to flow in to eastern moats. Three eastern moats were interconnected and the outward flow from the southern most moat was regulated at it's South East corner, before discharging in to a channel which carry them through to the Isurumuniya, the Vessagiriya, and other surrounding landscape features, before final discharge in to Malwathu Oya.

Refer page 23(a)

Fig 2.8 Layout plan – Floor line Analysis of Ranmasu Uyana
S.Manawadu- 1992

Conclusion

The Ranmasu Uyana both as monastery and as a Royal pleasure garden, displays the construction ingenuity of ancient Sri Lankans and their mastery of reservoir systems. It is a reflection of this society's, technical skill and many other cultural attainments. The Ranmasu Uyana is a reservoir system in micro scale, and is a part of a major reservoir system. Its constituent elements are excellent examples of the direct and indirect influences of hydraulic systems on the built form of the dry zone living environment.

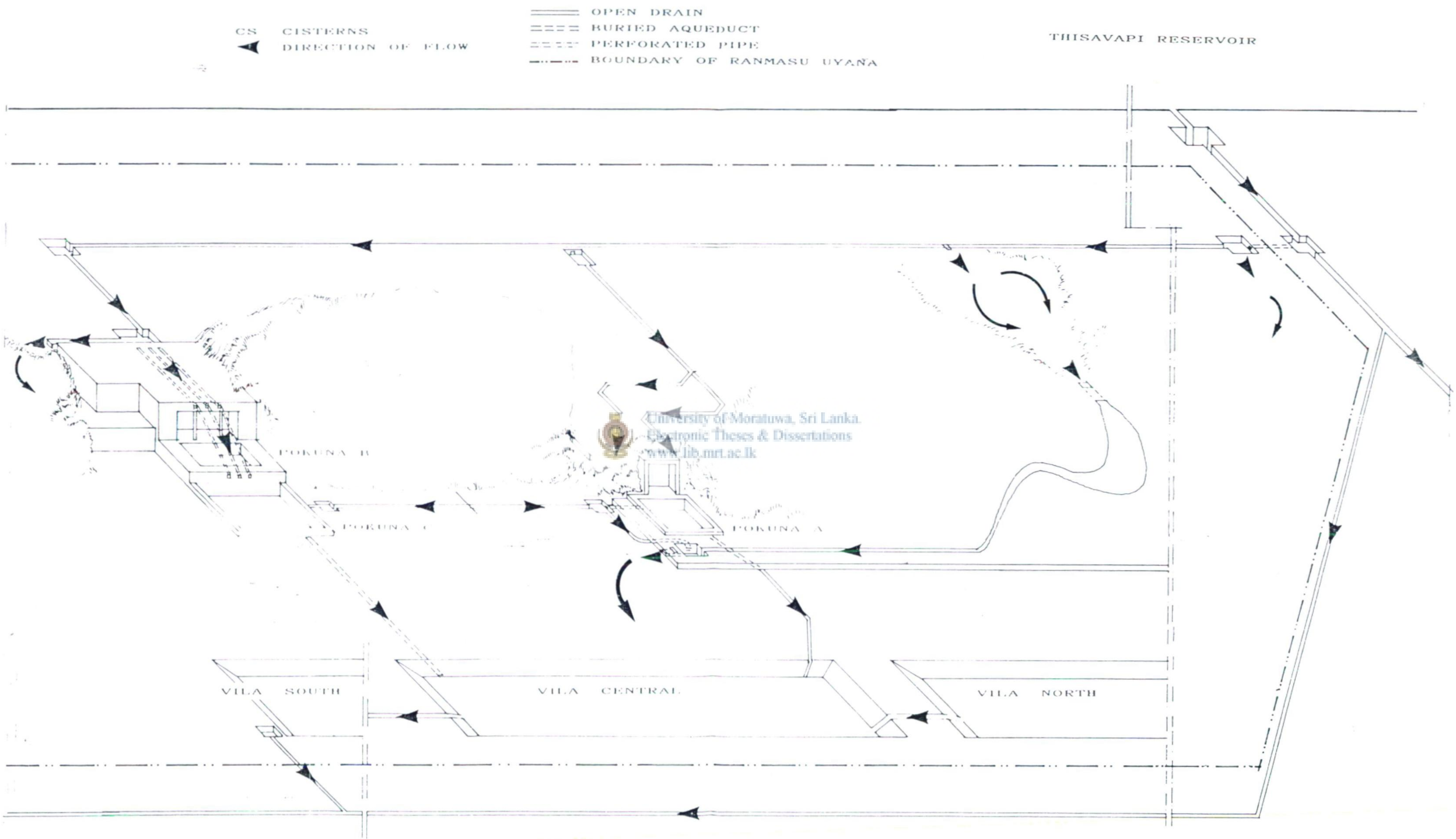


Fig. Flow line analysis of Ranmasu uyana.
(Source Dr S. Manawadu -1992)

2.4 HYDRAULIC STRUCTURES AND ITS DEVELOPMENT

2.4.1 Retention Structures

Water retention structures are the most important elements of a hydraulic system and they comprise manmade works to impound water. Size, shape, and functions were developed due to the needs of Sri Lankan villages, towns & cities to sustain their built environment. Four basic types may be identified in the dry-zone of Sri Lanka: The vapi (wewa or kulama), the samudra, the villa and the pokuna.

2.4.2 Distribution Structure

(a) Biso Kotuwa- Sluice

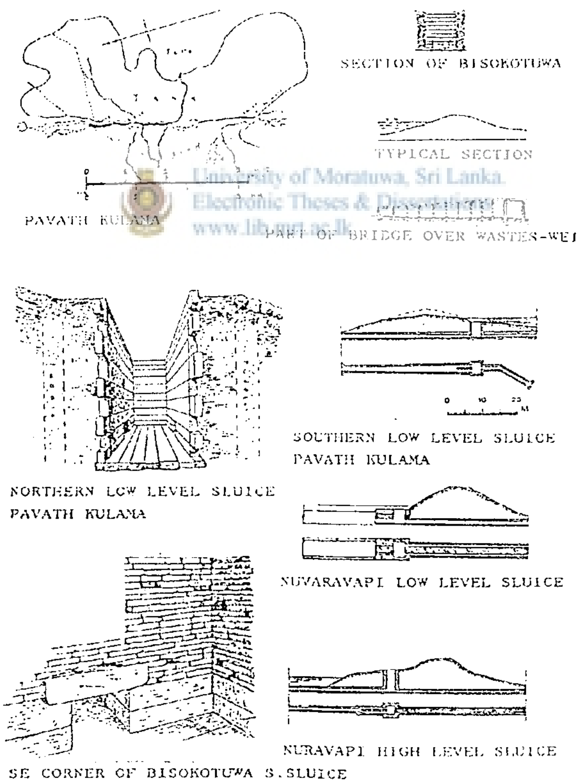


Fig: 2.9 Typical " Biso Kotuwa" of a Reservoir System
Source- Henry Parker, Ancient Ceylon

The Biso Kotuwa can be considered as the oldest version of the modern sluice and functioned as a valve pit. Biso Kotuwa discarded water into the channel called Ela which was the major conveyance structure. Water was conveyed into Biso Kotuwa by one or two channels, open or closed depending on the reservoir capacity.

Cut stones were used to make early kinds of Biso Kotuwa and later on bricks to give a very smooth finish. Structurally and functionally the modern sluice is similar to the ancient Biso- Kotuwa. Hence the Biso Kotuwa can be considered a most advanced structure in Sri Lankan civilization.

(b) Ela- Channels

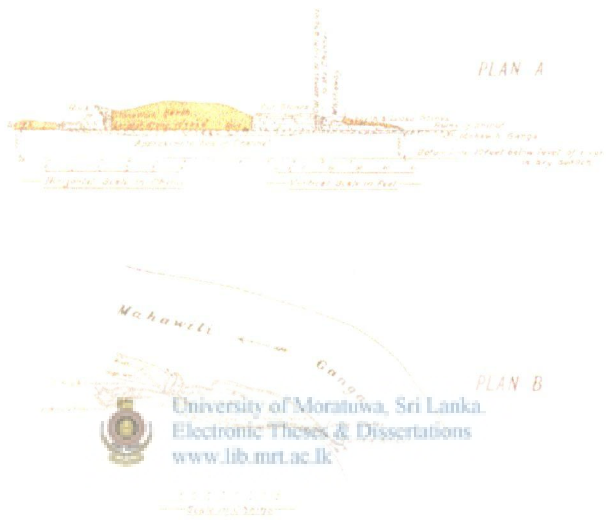


Fig: 2.10 Typical Chanels in "Yodi Ala"

The Ela connected to the Biso Kotuwa through, buried aqueducts, and flow was controlled at the Biso Kotuwa. The highly developed technology was applied to achieving and maintaining a very gentle slope gradient.

2.4.3 Protective Structures

We can identify the following major types of protective structures in hydraulic design.

(a) Diya- Pannuma-(Waste weir)

Waste weir dischargesurplus water when the impoundment exceeds the High Flood Level (HFL) of a reservoir. The place selected is typically natural rock bed which forms part of the embankment. Fountains are often used as the High Flood Level indicator. The Fountains of Sigiriya water garden were most probably used as a “Flood level indicator” of the Sigiriya wewa. Nowadays the Sigiriya water fountains are working during the heavy rainy season.

(b)Pannuma- Ela-(Overflow Channel)

The opposite bank of the Pannuma was connected to another channel called Pannuma-Ela. This overflow channel usually carried surplus from a reservoir back to its original source at a down stream location. It is very sympathetic to the ecology of the water body, as it helps maintain a full range of aquatic plant and animal life.

(c)Ralapanawa- (Embankment Protector)

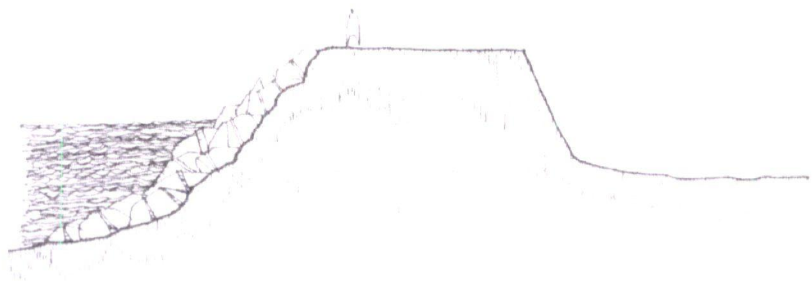


Fig - 2.11 Sectional Elevation- Tank bund and Ralapanawa

The Ralapanawa is used to protect the reservoir bund from erosion by high wave action. Stone and soil layers are traditionally used to make Ralapanawa. This technology has been developed for use along large reservoir embankments.

Fig - 2.12 Section through typical ancient reservoir embankment

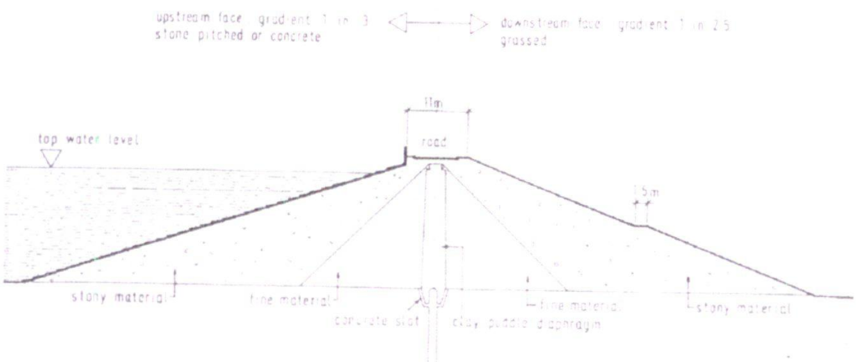


Fig - 2.13 Section through typical modern reservoir embankment

Chapter Three

3 LANDSCAPE CONCEPTS AND DESIGN PRINCIPLES AT SIGIRIYA

3.1. SITE SELECTION AND DESIGN

"In ancient city planning and selecting s site for an urban landscape, it is possible to identify the planning principles adopted in creating a built environment while integrating and enhancing the aesthetics of natural elements, vegetation and water"[1]

When selecting a site for the fortified garden city of Sigiriya, in addition to being a strategic point for protection and safety, the topography, aesthetic and availability of water was also given priority. According to the social and political background of the Kasyapa period (477AC-495 AC) Kasyapa wanted both physical security and mental pleasure. As such he did not like to remain in the capital city of Anuradhapura. He selected Sigiriya as a capital city in 477 AC. The water potential and its topography are its major features. The site and also the design concept developed according to the water potential of the Sigiriya wewa and the Sigiriya oya.

Fig 3.1- Sigiriya Oya in rainy season

1. Nimal de Silva ,Landscape Traditions of Sri Lanka, Colombo, 1996

Pre Kasyapan period Sigiriya was used as a monastic place. The native traditions tell of the occupation of Sigiriya by aboriginal yakku and later times its solitude must have attracted the monks.

A local tradition connects the rock with king Devanampiyatissa ,who reigned about 226BC.They say that the king found on the rock a golden bamboo which had three trunks called yako-yahkti, kusuma -yahkti and yakuna –yahkti. In the first trunk there were golden figures of a woman, in the second golden flowers, and in the third golden figures of gods. The king said "let this rock be always remembered by me". Hence "Sigiriya" became a remembrance rock.

Fig 3.2- Arial Photograph of Sigiriya

The distinctive inselberg "Sihigiriya" became the "Sigiriya" royal residence in the 5^{th} century AD under the guidance of king Kashyapa and his architect. Sigiriya, within and without its walls was integrated within a large irrigation system.

The various parts of the site were designed with specific land uses in mind; the summit of the rock was reserved largely for the royal residences and related service buildings. The flat area of land west of the rock, were developed as the royal pleasure gardens. All man- made elements in the site layout, such as moats, ramparts, paths, ponds, pavilions and so on were placed in a systematic order within a beautifully identifiable grid. But the utilization and the integration of natural elements like caves, boulders, slopes and levels within the formal axial pattern was skillfully done by harmonizing the beauty of both symmetrical and organic layouts. The designer used all the typical hydraulic devices, channels, sluice gates, pressure chambers, weirs, orifices, notches and channels to control the play of the water in enhancing the beauty of the Sigiriya pleasure garden. (Fig: 3.1)

3.2. Design concept and foreign influences

"The landscape design concept may be defined in few words in terms of the environmental quality of the site". [1]"The rocks, the water and the earth in all our little gardens and larger parks are part and parcel of the continuum of earth, rock and water which together with the atmosphere in which we our selves live, are the basic environmental elements of the Nature."[2] The design concept of Sigiriya pleasure garden responds mainly to its two major landscape features- its water and its rocks.

At Sigiriya both the dynamic and the static qualities of water are expressed in its gardens.

1. Nammuni Vidura Sri, SLIA Journal Vol 101-No.5

2. Ecology & Landscape ,Jum. C.G. London:1966

3.2.1. Preliminary study of water-based landscape concepts

- **ORIGINS**

The first landscape designs exploiting the effects of irrigation in garden layout were developed from agricultural practices. The fenced vegetables patch and its pattern of water channels were the original prototype and it was taken over and elaborated in the gardens of a leisured aristocracy in the first centuries of civilization along the Tigris, the Euphrates, the Nile and the Indus. Here it was often expressed in the form of an earthly paradise exploiting the pleasurable sensation of water flowing in channels and ponds.

3.2.2. Foreign influences and developments

The King Kasyapa was not the first person who commenced work at Sigiriya. The king Datusena had started building a palace which he failed to complete and therefore abandoned. The motive behind the attempt to build a palace on this rock is to attain "PARVATHA RAJA – SHIP" which was an eastern concept of kings dwelling like the Kuvera and palace to behold link another "Alokamanda" were considered a requirement to achieve the same concept and water has been used abundantly for this purpose.

"The date of the Sigiriya is clearly established. The Chulavamsa records that the king Kashpaya. (477-495 AC) built the palace on the rock with the lion staircase –house, ramparts and the gardens. Past and recent archaeological excavations have confirmed that the gardens substantially date from the 5^{th} century. They have also revealed elements dating from several post Kashyapa phases extending from the 5^{th} to about 13^{th} century"[1]

1. S Paranavithana, The story of Sigiriya Col 1972.p22

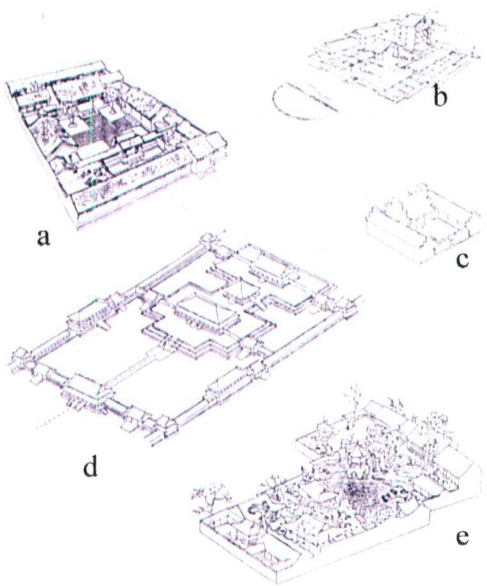
While international parallels and correspondences with Sigiriya are worth mentioning in passing care should be taken not to place too much emphasis on foreign influences on Sigiriya or Sigiriyas influences on foreign tradition. The clearest parallels to the water garden at Sigiriya are to be found in the much more ancient geometrical gardens of Egypt and the early paradise gardens of ancient Persia. It should be noted however that Sigiriya's achievements predate Moghal paradise gardens and those of Renaissance Europe. "Of the ancient gardens of the world that survive in an archaeological sense the only significant examples that predate Sigiriya and are equally well preserved are those of the Romans such as the private and the public gardens of Pompeii and Herculaneum, (Jashemski 1979) and the imperial gardens of Hadrian at Tivoli (Kahler1959).It is worth recalling some of the characteristics of these Roman gardens."[1]

Imperial Rome and its Mediterranean territories had close trading links across the Indian Ocean to Sri Lanka and the Indian seaboard. Roman coins prove these connections. Roman gardens were, like those of Sigiriya, geometrical compositions, expressed partly in a pattern making which used basins and tanks of water collected from the roofs of adjoining buildings, and on a large scale from diverted water courses. They included shaded walls, fountains, fruit trees, herbs and chipped borders of ever green, and usually also small altars at which offerings could be made to the guardian gods and goddesses. (Jashemski 1979)

1.S Paranavithana, The story of Sigiriya Col 1972.p22

The archetypal elements of the quartered pools of Sassenian paradise gardens were however contemporary with those of Sigiriya and their surprisingly close resemblance is probably not mere chance since traiding links between the two countries were known at this time.

"Both the water gardens and the boulder gardens at Sigiriya have eastern parallels. The closest parrell to the Sigiriya gardens are the gardens of China, Indonesia, Korea and Japan. Sigiriya's connections with China and especially with Mahayana traditions, is a rich and long standing one. (werake 1983)and while there is no basis to suggest any degree of direct influence of Sri Lankan gardening on the far eastern traditions, it is illuminating to compare the two traditions. In this connection we may usefully quote Andrew Body's remarks on the "the combination of symmetry and asymmetry in Chinese architecture & garden planning. (Fig 3.3) The house and the city were ruled by Confuscian ideas of formality, symmetry, straight lines, a hierarchy of importance, clarity, conventionality, and manmade order. The garden and the landscape on the other hand were formed along typically Taoist conceptions of irregularity, asymmetry, curvilinear, undulating and zigzag forms and the "imitation of Nature".[1] (Boyd 1962,).



a. Court yard house in Northern ,China.
b. Collective house family clan ,Fugian province.
c. Taibe Dian imperial palace, Beijing.
d. Court yard house, Yikeyin in Southern,China.
e. Chinese garden, Wangshiyuan

Fig 3.3 Axial and Symmetrical layout of Classic Chinese Traditions

1.Bandaranayeke S. ,Sigiriya and Sri Lankan art of gardening, unpublished research paper

The third garden form at Sigiriya ,the lower terraced gardens, have parallels in many other ancient &modern cultures in both the East & the West. They for example are quite often encountered in early Indian sites. (Allchin , 1982)and are a conscious element in Chinese lawn planning landscape gardening and architecture. The diversity of parallels and correspondence that we see in the garden at Sigiriya serve, in the end, only to underline the uniqueness of this fifth century creation of the Sri Lanka master builders and engineers.

3.3 Water uses for landscape design in Sigiriya

The Sigiriya complex comprises of a summer palace and pleasure garden, a skirting boulder garden, and lower terraced gardens, with the whole, enclosed in a moated rampart. The landscape design concepts and principles depend on the hydraulic potential of the Sigiriya region. Five major features are closely identified with water.

Sigiriya wewa-Sigiri oya

The reservoir which is in the vicinity of the rock is called “Sigiriya wewa”. It is the major source of water and is fed by Sigiri oya. The Sigiriya wewa was built by damming Sigiri oya and sustaining water on the low lying area between the dam and the adjoining high ground.

Fig: 3.4 View of Sigiriya rock over wewa (SLT Year Calender)

Dr. Paranawithana conjectures that this reservoir was not constructed simply to give water to the paddy fields for the purpose of cultivation but was constructed in order to show the rock like mount Kailasa, rising from the water (Fig3.4), to boost the image of Kassapa as Kubera.

Whether or not Dr. Paranavithana's interpretation is correct, the view of Sigiriya rock across the wewa with its reflection is strikingly simple and bold.

The moats as landscape elements

Rectilinear outer moats (Fig 3.5) were constructed around the whole garden giving it a geometric formality. These were no doubt partly to give protection against sudden attack, & partly to ensure the privacy of the king and his court. Some are aligned on distance peaks which are reflected in the water, among the water lily planting.

Fig 3.5: Sigiriya outer moat, showing retained inner embankment and water lily planting

Ponds and pools

There are many ponds and pools in Sigiriya fed in sequence of gravity flow. They are found in various locations and in various shapes and sizes.

Fig 3.6 – Plan of the Sigiriya Complex

The first enclosed water garden found at the western entrance consists of four pools and a raised pavilion on each side of the main West –East axis. As described earlier the pavilion probably built at the centre of four pools and the enclosing are large enough to suggest a range of walls communal uses including bathing. At times of full moon their reflection quality helps considerably to light the pool surroundings. It is possible that this pair of 4 ponds axially arranged relates to the four quarters of the Buddhist world, just as do the two main interesting axis of the whole composition.

Fig 3.7 – Sigiriya, Lowest Garden. Long rectangular stepped pool to maintain display as water level drops.

Next to these and further east is a long narrow walled enclosure possibly for the private use of the King, with a long narrow stepped pool (Fig 3.7) on each side, possibly used for bathing. Above these are two small square pools with fountain jets.

Either side set back outside the walls on each side of this narrow enclosure are two moated islands rounded up to take central pavilions. What remains of these and their moats suggests less formal ground modeling, possibly in transition to the adjoining boulder gardens. They offer good views down and around to west.

Fig 3.8 "A marriage of formal octagonal shape of the water and irregular shape rock boulder

The octagonal pond and rectangular pond which were located at the foot of the boulder garden on either sides of the main path to the rock (fig.3.8) are the next form of ponds. The octagonal pond was enclosed by a wall, probably for privacy, and served by a cascade shower.

Fig 3.9 "Sigiriya, View of the location central pavilion & surrounding 4 pools

Rain water falling on the summit was carefully collected from the palace roofs and led down to the central tank at the heart of the whole complex. From there it was led westward to help supplement the Wewa water supply to the garden. The views down from the surrounds of this tank out over the whole of the lower terraces and pools glistering in the light is breath taking and it is not hard to believe Kassapa's success in projecting the image of a god king & of greatly impressing all those who visited him in his rock top palace.

Fig3. 10 "Plan of the summit"

Fountains

The fountain jets previously referred to on either side of the western approach axis, (Fig 3.11) are still in working order and when the Wewa is full, during the rains, they play their delightful jets.

Fig 3.11 : Sigiriya: west garden six small jets served by a pressure chamber

Near by, and their shallow pool, on each side of the main west axis.

Artificial rivers

Artificial rivers, a shallow stream of water in a natural organic path constructed in a rectangular garden space by the western access path, is regarded as the most extraordinary use of water in this complex and resembles that also used in the Ranmasu Uyana. Its serpentine shape is distinctively organic.

In this pleasure garden situated in the dry zone of Sri Lanka, the highly variable and imaginative use of water plays a vital role in achieving its objective of creating pleasure.

Fig 3.12: Sigiriya west garden serpentine, detail of brickwork

Water being one of the most essential and closely related natural element in a flexible fluid form, its motion pleases arouses human senses, creating pleasure. Creation of dynamic quality with dynamic shapes of ponds and novel experiences of symbolic meanings also evoke pleasure with no respect to the function and the period of which the architectural work was completed. Only the selection of grammar depends on those parameters.

3.4 Landscape for Defence

"The good environmental landscape image gives its possessor an important sense of emotional security"1 Emotional and physical security can be created by using appropriate landscape techniques, materials and correct scale. Sigiriya's landscape is a very good example of landscape elements used for defence.

3.4.1. Physical Security

Physical security depends on two major factors, scale and durability. In Sigiriya the outer and inner moats have been used for defence. The outer moat creates a surrounding marshy area that became the first line at defence for the citadel. The main entrance was very narrow. There was no permanent bridge, and it has very high steps with a security platform. (Fig 3.13)

Fig 3.13: Conjected western entrance
Sourse - Sihagiri- Dr. Malinga Amarasinghe

Other access corridors are also very narrow in width and some places act as Physical security areas, even today.

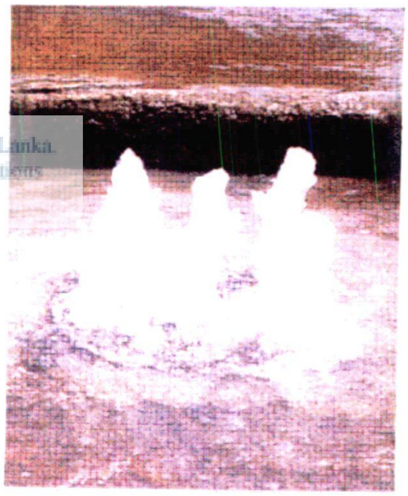
3.4.2 Psychological Security

Symbolism is important in the expression of psychological security. The Sigiriya designer makes good use of symbolism. The lion symbol is prominent. The high elevated rock outcrop rising from the flat surrounding plain also has a strong psychological impact. The mouth of the lion was directed to the north. (Figure 3.14) shows my interpretation of its original appearance.

Fig 3.14 Sigiriya: The lion platform, with a conjectival restoration of the lion.
Source- Sihagiri, Dr. Malinga Amarasinghe

Sigiriya was so designed so that no entrance could be taken direct. Entrances were interrupted by terraces and ponds staggered stairways, narrow paths and narrow arches. All these landscape elements created psychological and physical defence.

For all its supposed psychological & real defensive strength Sigiriya was not strong enough to prevent Kassapa being defeated by his brother Moggalana and the whole complex, after fitful use as a monastic retreat falling into neglect and being reclaimed by the jungle.

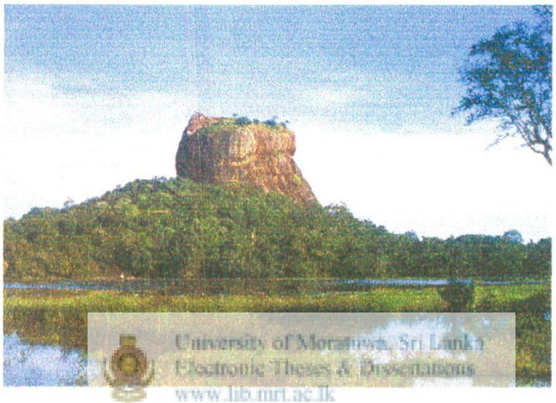


Chapter Four

4.0 THE HYDRAULICS OF SIGIRIYA'S LANDSCAPE

4.1 HYDRAULIC POTENTIAL OF THE SIGIRIYA REGION

According to the hydraulic engineering, the "hydraulic potential" can be defined as; "The ability to store water in the higher level, with respect to the ground level and it is formed the gravitational energy by water in the particular region the hydraulic potential depends on the rainfall, soil condition topography, water sources, and elevation of a particular region."[1]



(fig. 4.1)

In the Sigiriya Dambulla region there are seven major river basins (fig. 4.2) such as Kiri oya basin, Sigiri oya basin. Mirisgoni oya basin, Dambulla oya basin, Gal oya basin, Hirati oya basin, and Havanalla oya basin. In the Sigiriya region, there are two major potential sources of water, (fig. 4.2) the Sigiriya wewa. Other one is large man made ponds on the rock and its. Served ponds, and which are served by the Sigiriya oya and Mirisgoni oya.

1 Smith K.L. The Hydraulic Applications, Oxford University press 1972.

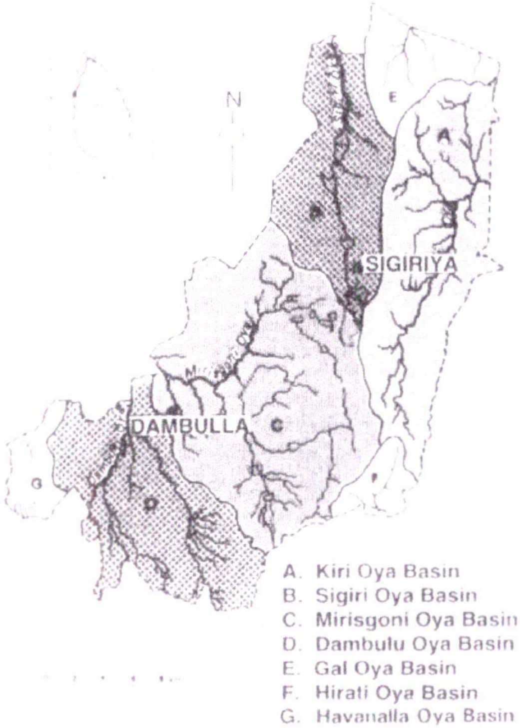


Fig. 4.2 Sigiri Oya Basin Topography with Sigiri Oya & Sigiri wewa

The hydraulic potential of the Sigiriya palace complex is very high due the higher of it's rock some two hundred meters above the surrounding plain and the heavy rain comes to the top of the palace due to high condensed rock clouds. There are direct connections from palace ponds to the water garden. Sigiriya wewa is another continuous water source. Its elevation is seventy-five meters (MSL). We can directly say the most effective hydraulic potential is providing water to the water garden, specially water fountains. When water filled the Sigiriya wewa and the connected octagonal pond, the water jets were activated automatically. Technology behind this was the Natural hydraulic potential of water.

4.2 RESERVOIR SYSTEMS OF SIGIRIYA REGION

4.2.1 IRRIGATION SYSTEM OF THE SIGIRIYA REGION

The Sigiriya complex falls within the ancient irrigation district described today as the Innamaluwa Korale or the Sigiriya Region. The hydraulics of the Sigiriya complex therefore constituted a component part of the ancient drainage system in the area, which was irrigated by the Ancient Sigiriya Wewa. Some understanding of the ancient irrigation system in the Sigiriya Region is hence essential to appreciate the relationship patterns that existed between the Sigiriya hydraulics and the other systems of irrigation in the area.

According to Bell's 1908 Archaeological survey report:

"... The (Sigiriya) tank (confined at the present day to a small lake with a short bund joining up Sigiriya gala and Mapagala rock suffice to hold up) extends as its large far stretching embankment long overgrown, testifies, in a south-westerly direction for some five miles until it strikes the nearest hills at Kandalama..."[1]

In a survey of ancient irrigation work covering the Tamankaduwa District, documented in the Ceylon Administration Report of 1888, Blair made the following observation on the same topic:

[1] Archaeological Survey Ceylon Report, 1908 Bell H.C.P. Ceylon 1904. P. 12.

"... A glance at the map shows the striking fact of how close this huge tank is to its own watershed-so much so that its drainage area cannot be more than treble its own area. This is not nearly sufficient to fill a tank of such an area and depth. (Approximately 1,000 Acres at a average depth of 10 feet) and I strongly suspect that there must have been a supply channel for it, tapping the Kiri-oya a mile or two south of Alakola Village..."[2]

"This extensive ancient irrigation system that functioned from the Sigiriya Wewa is longer extant except for a few traces of canals seen as water courses from the breaches of the tank bund. Blair has suggested that the ancient sluice gates may have been located at these points. The Sigiriya Oya originating at the Northern end of the Sigiriya Wewa may b regarded as the main irrigation canal of this ancient irrigation system, since it extended northwards to supply the Hiriwaduna Wewa on the border of the district."[1]

The traverse of the Sigiriya Oya ran along the Western Boundary of the Sigiriya complex and collected the outflow from the Citadel along its downstream path. This connection at the lower end of the complex linked the hydraulic systems of the Sigiriya Citadel with the main irrigation system of the Sigiriya region. A similar channel connection from the upper regions of the Sigiriya Wewa irrigated the Citadel complex.

1 Ceylon Administration Report, 1898, Annexure B. Blair Ceylon Government Press

2 Ellapola C. Ancient Ceylon No. 11 Vol. 5 Dep. Acheaology Colombo 1990.

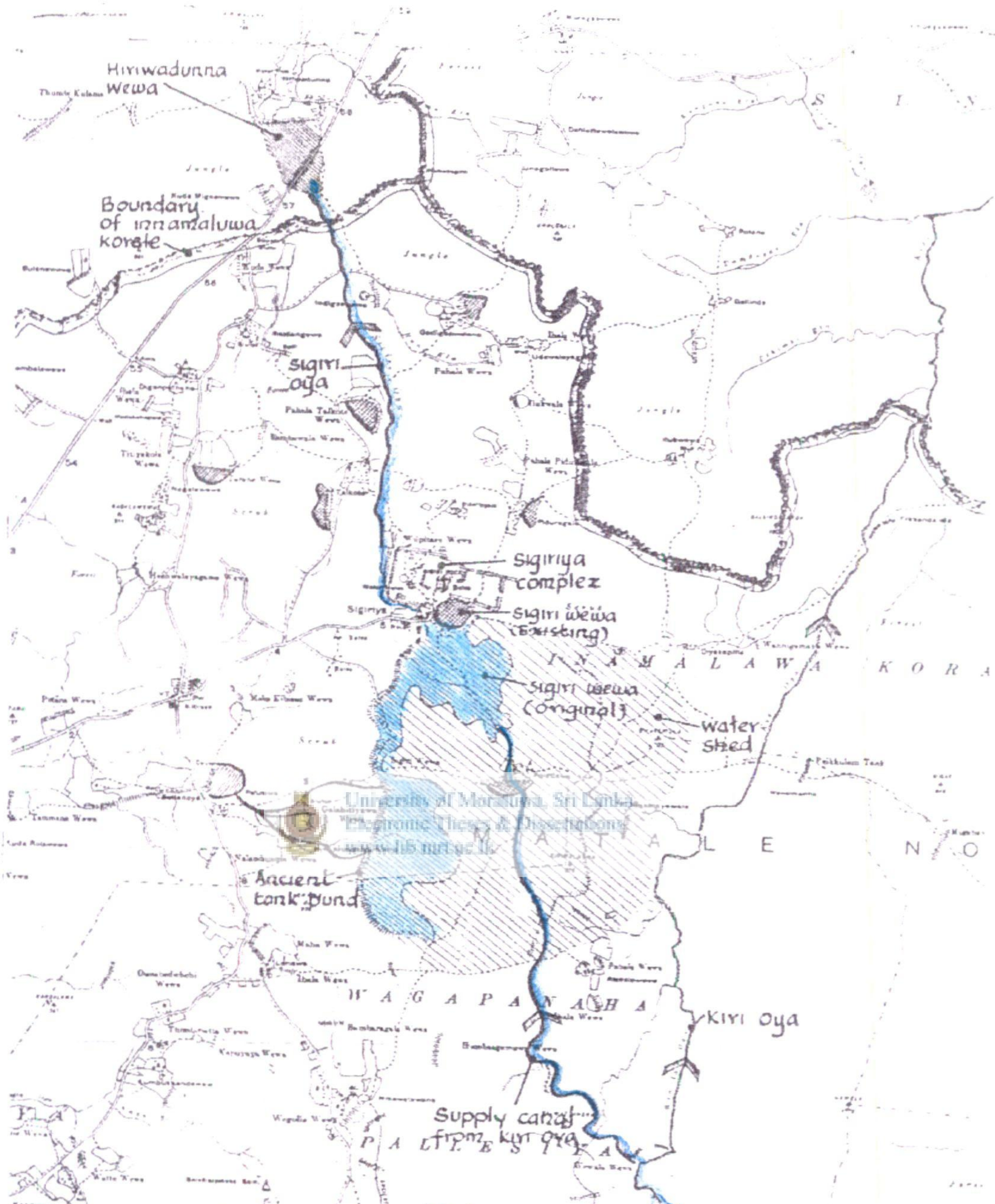


Fig 4.3 – Irrigation Pattern of Sigiriya (Archeological Survey Report 1990)

4.2.2 INTEGRATED MACRO DESIGN CONCEPT

The Hydraulics of Sigiriya may be considered as a composition of many specialized systems that were engineered to serve the diverse needs of the Citadel. Although these individual systems functioned differently, their component parts were intricately inter-related to form a single comprehensive network by means of numerous by-pass and loop connections. This facility permitted parts of the system to continue working while other sections remained closed, facilitating the processes of repair, maintenance or even water conservation.

The water flowing through these different hydraulic systems within the Citadel was passed out of the complex and collected into channels that finally emptied the water into the Sigiriya Oya. Downstream irrigation of the region was thus ensured with the water conserved from within the Sigiriya complex.

4.3 WATER DISTRIBUTION CONCEPT

Water distribution through the complex was controlled by gravity action, which created a gentle flow into the successively lower areas where the supply was required. The horizontal dispersal of the water was primarily channeled through underground conduits. Therefore, the sub-surface of the Sigiriya precinct may well be imagined as a maze of water lines, no different to any modern service layout.

A common construction detail characterized these underground ducts. However, their crossectional dimensions varied according to the volume of water they conducted. The typical conduit had its base and sides constructed in stone work, and was covered with a stone slab. When the drain was wide, the span of the cover slab was reduced by a supporting cross wall that divided the drain into two parallel chambers.

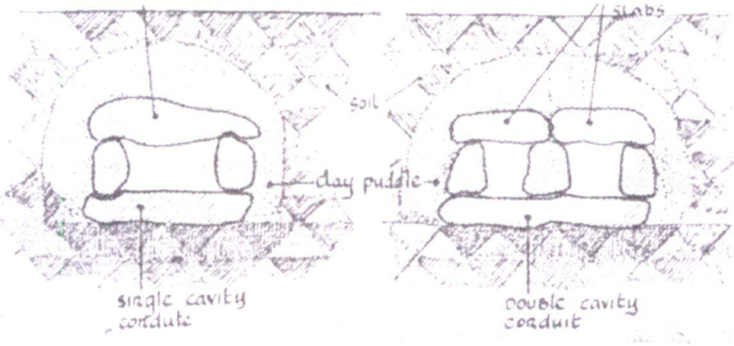


Fig 4.5 Horizontal water distribution

The entire conduit was surrounded in a "puddle" of tamped clay which acted as a waterproofing on the outside. Since the system was not under pressure the outward diffusion from within the conduit was negligible and was further retarded by the waterproof barrier of clay.

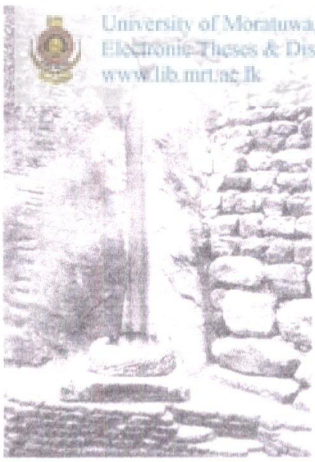


Fig 4.6 Vertical drain , Boulder Garden - Sigiriya

When the continuity of the conduit was broken, it discharged water to the outside, creating an empty cavity within the conduit that caused the conditions of a reverse flow of water into the conduit. In this process, particles of soil entered the cavity of the conduit and the heavier material remained when the water drained down. In time, the soil deposit accumulated to block the entire free passage of the conduit. The restricted flow caused further damage to the hydraulic system. The conduits exposed by excavation were often seen in this condition, filled with earth.

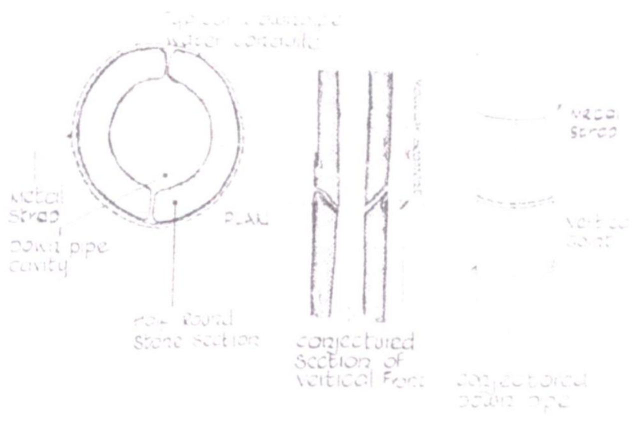


Fig 4.7 – Details of vertical water distribution
Source- Ancient Ceylon,1990

Downpipes were employed to effectively transfer water in a vertical plane. They were sometimes found placed underground, to connect Drop Manholes. Attached to masonery walls they served to conduct drainage from higher to lower levels. Typically these pipes consisted of two half sections in stone, held together by a metal strap. Modular segments were employed to extend the length of the vertical pipe run as desired.

4.4 HYDRAULICS OF THE "SIGIRIYA COMPLEX"

4.4.1 HYDRAULICS OF THE WATER DRAINAGE SYSTEM

"The ancient designers of the Sigiriya Complex were obviously conscious of the inevitable disaster, that could result from poor site drainage. They had probably envisaged the common scene of floods that occur today, with the advent of the seasonal Monsoon rains.

To solve the problem they had developed the site with a sensitive regard to its unique topography, and had planned a drainage pattern to accommodate the substantial volume of rainwater run-off that flowed down the sloping land formation, surrounding the Sigiriya rock outcrop."[1]

The Western side, of the Sigiriya Complex was landscaped into a series of stepped garden areas that have been described as the Terrace Garden, Boulder Garden, and Water Garden, in respective order of descent, along the Western slope. These areas performed the vital function of regulating the downward drainage as it flowed through the various hydraulic features of the gardens. Most of the water on the Western slope and some part of the water from the Summit of the Sigiriya Rock, eventually entered the lowest garden area of the western precinct. However, the effective drainage measures that had been adopted prevented the natural free flow of run-off water on the surface of the site and thereby eliminated any possibility of site erosion.

Bell's Archaeological survey of the complex in 1898, "identified on the map, five water collection and storage ponds on the western side, positioned along the toe of the slopes skirting the Sigiriya Rock. From their location and distribution it is apparent that these functioned as drainage catch basins for the rain water run-off from the upper reaches of the Terrace Garden area (excepting

1 Bandaranayake Senaka Archeaological Survey Report, 1992.

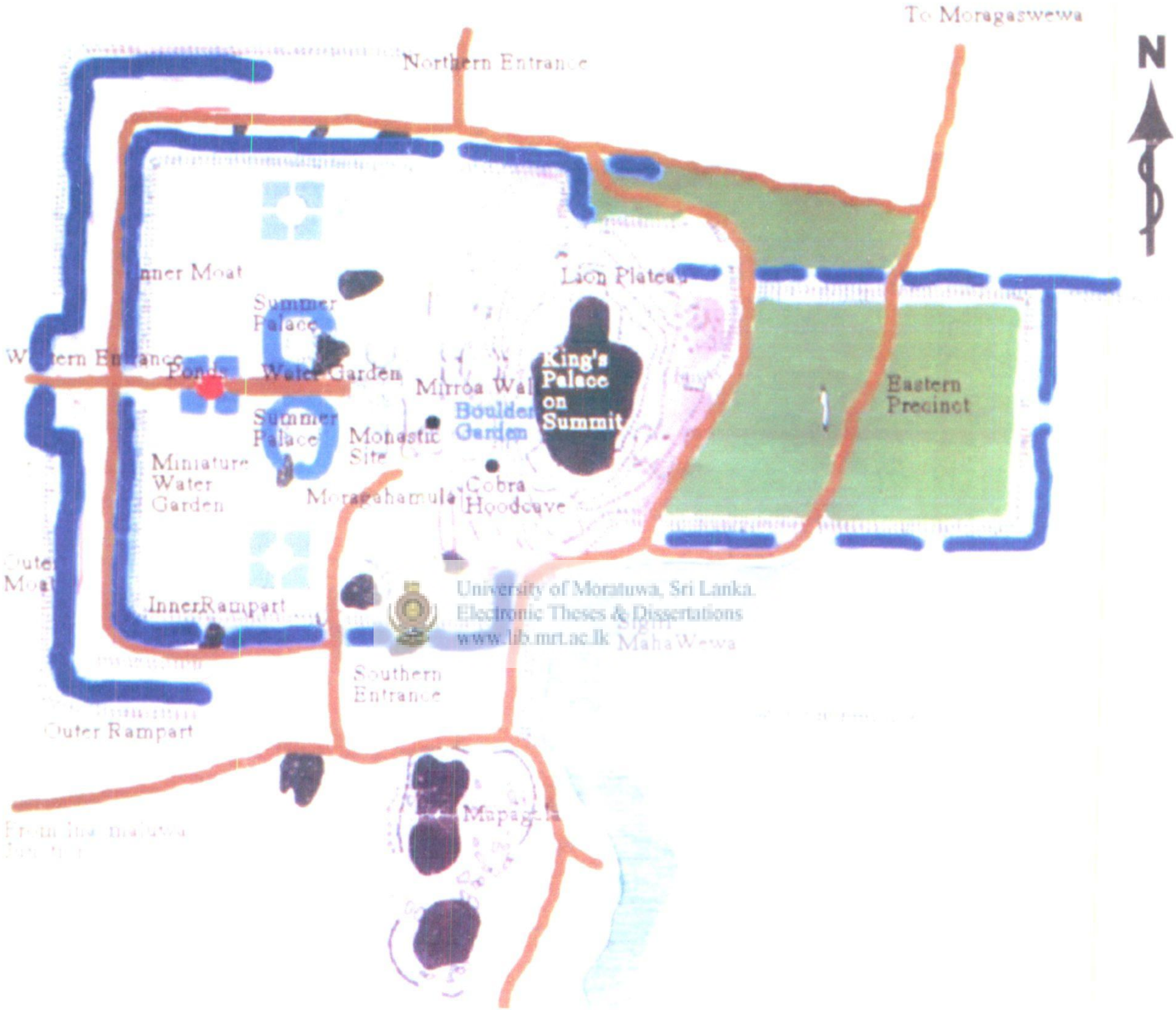


Fig 3.6 – Plan of the Sigiriya Complex

the "octagonal pond" that has been restored in modern times, the other ponds still remain unexcavated)."[2]

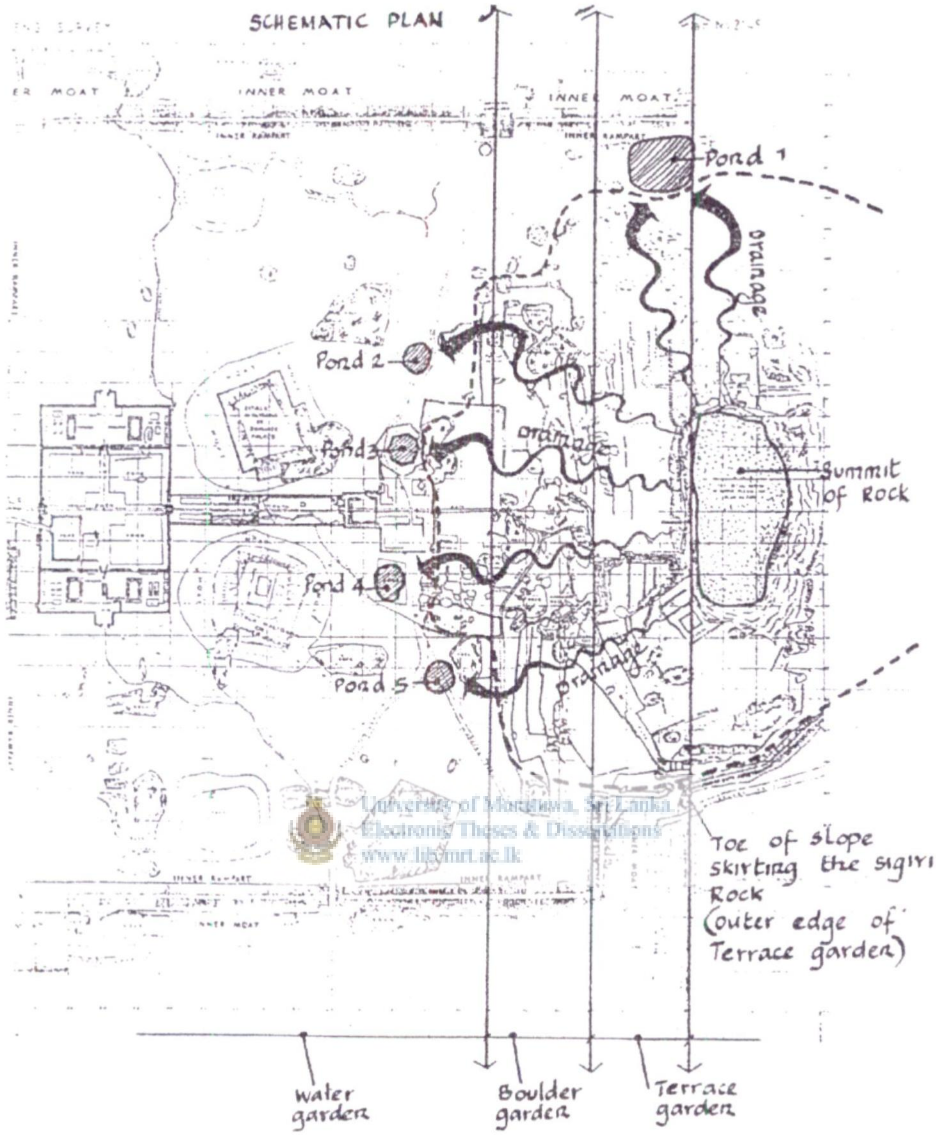


Fig- 4.8 Hydraulics of the Water drainage system,

Source – Ancient Ceylon – Colombo 1990

The point of discharge was often the location of a natural boulder which was invariably grooved with a channel on its vertical face to carry the water. Such a discharge system possibly drained the entire upper terrace region into the discharge catch basins or "Ponds" located at the outer edge of the Terrace

2 Archaeological Survey Ceylon Report, 1908 Bell H.C.P. Ceylon 1904. P. 12.

Garden area. The drainage lines that existed as separate discharge channels, drains or conduits, were apparently linked into an irrigation network through Gulleys and Man-Holes. At these junction points, the system often changed its mode, from a surface to an underground path, or altered its direction of drainage to a different course.

The drainage from the Western Sector of the Sigiriya Rock summit was designed to enter the Western precinct of the Garden. The water run-off was directed into a catch drain cut in the rock, that extended North to South on the Western cliff. A vertical channel on the face of the cliff at the south end carried the water down to a receiving cistern built into the terrace at the base of the rock. The extended hydraulic system from this receiving cistern has been conjectured by Bell as follows :

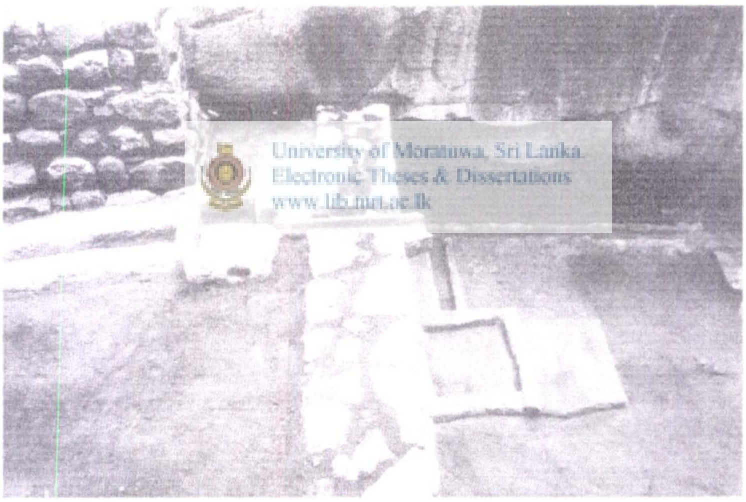


Fig 4.9 – Drain & Silt-trap, Boulder Garden, Sigiriya
Source – Ancient Ceylon, 1990

"... a single drain passed through the Western wall of the cistern and it is hardly rash to surmise that the bath on the" cistern rock' was supplied by an overhead aqueduct across the four intervening terraces...".[1]

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1 Archaeological Survey Ceylon Report, 1908 Bell H.C.P. Ceylon 1904. P. 12.

In any event it is clear that the water from this cistern, at the base of the rock, passed into underground conduits and eventually reached the storage reservoirs at a lower level, distributed in the Terrace Garden area.

4.4.2 HYDRAULICS OF THE WATER SUPPLY SYSTEM

The existing bund of the Sigiriya Wewa appears to match a topographic contour elevation of approximately 200 feet. Most probably this level was even higher during ancient times. It is therefore, logical to suppose that the Sigiriya Wewa had the hydraulic potential of irrigating the entire plain, below the contour assumed at 200 feet.

"This critical height, defined by the contour at 200 feet, crossed the topography of the Sigiriya Complex almost along the outer limit of the Boulder Garden area on the Western precinct. The chain of garden pools (or drainage basins) lying immediately below the Boulder garden area were thus easily irrigated with a water supply from the Sigiriya Wewa. Possibly there existed an underground conduit linking the Sigiriya Wewa to the pools, running along the 200 feet contour line. This direct supply connection from the Sigiriya Wewa may have been a standby facility to supplement the water collected in the pools from the surface run-off".[1]

The hydraulic conditions on the skirting slopes that surround the Sigiriya Rock may be assumed to be essentially uniform. Therefore, the hydraulic systems designed for the western side were in all probability appropriately applicable around the rock. On this basis it may be surmised, that the Sigiriya Rock was encompassed by an underground conduit, forming a complete circuit at the 200 feet contour level. A loop conduit system was thereby feasible, ensuring an economic and uniformly even distribution of the water supplied from the Sigiriya Wewa.

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[1] Ellapola C. Ancient Ceylon No. 11 Vol. 5 Dep. Acheaology Colombo 1990.

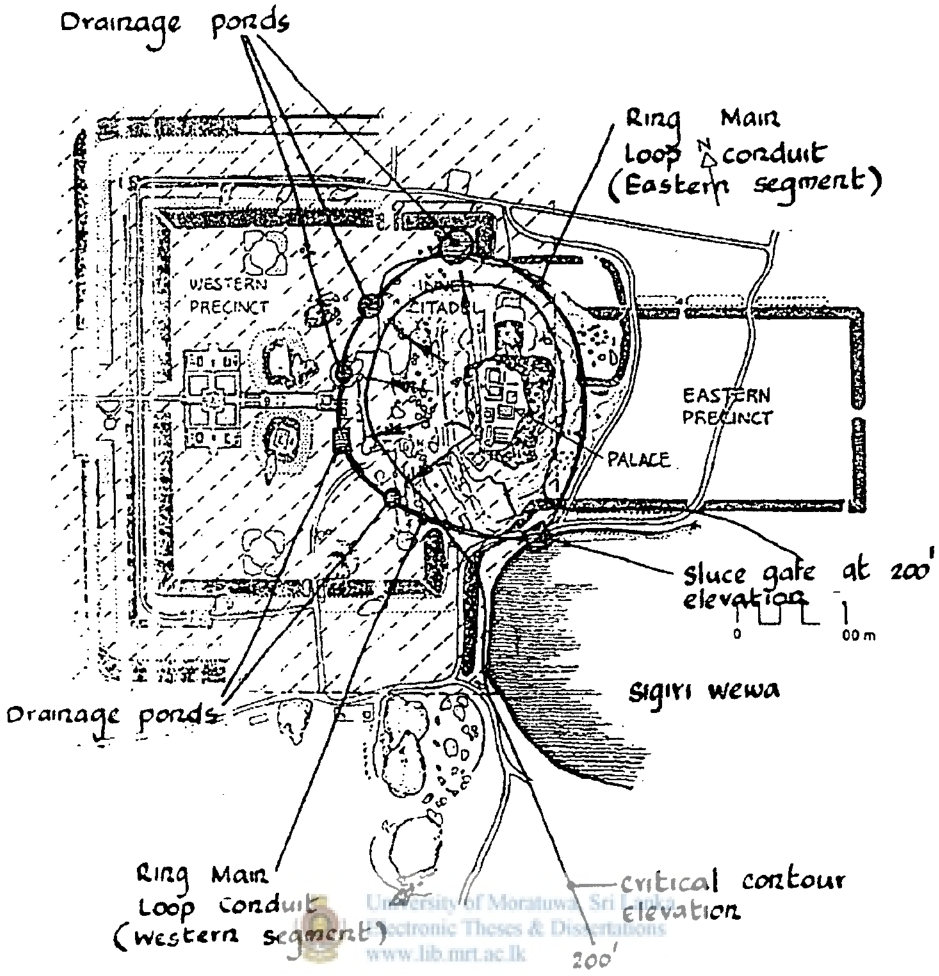

Fig 4.10 Hydraulics of water supply system.

Source– Ancient Ceylon, 1990

4.4.3 HYDRAULICS OF THE GARDEN AREAS

The stepped landscaped gardens on the Western precinct, changed their apparent design character from the formal pattern seen in the Water Gardens of the lowest level to an asymmetric organic layout, observed in the Boulder and Terrace Gardens, at the upper levels. Ornamental hydraulic features of an engineered nature were therefore, more aesthetically appropriate in the lower formal gardens than in the other areas. The highest hydraulic pressure head in the water distribution system was also experienced in the garden at the lowest elevation. Hence the Water Gardens of Sigiriya were ideally located within the final descending step of the slope on the Western precinct :

The upper reaches of the same slope probably acted as a natural soak away, absorbing and retaining the free run-off, only to release water into a controlled hydraulic system within the water garden area.

A concentration of display hydraulic features are found in the Central area of the Water Garden. This section extends from the inner embankment of the Inner Moat to the limit of the Inner Citadel Wall, on either side of the central pathway leading to the summit of the rock. For convenience of identification this segment of the Central Water Garden has been given an easy nomenclature as GARDEN - 1, GARDEN - 2, GARDEN - 3, AND THE MINIATURE WATER GARDEN.

Fig 4.11 Central water garden complex, Sigiriya
Source– Ancient Ceylon, 1990

GARDEN NO. 1 (Figure 4.11)

There are four large ponds at the centre of this garden area, arranged in a configuration similar to a typical Mughal chahar bagh.

Apart from being an obvious adornment to the landscape, these ponds also appear to have served a recreational function as bathing pools. This was clearly evident in the manner of their construction. Flights of steps and a series of surrounding terraces gave easy access to the water. These pools also showed interior plastering strongly suggesting its function in the nature of contemporary swimming pools.

The Sigiriya Wewa would have supplied the pools with the required clean water through an underground conduit. Part of this water line was buried in the bed of the reservoir and extended to the lowest area in the base of the Wewa. This ensured a uniform and uncontaminated water supply even in a time of drought. The presently extant remains of this line is visible in the Sigiri Wewa with the receding water line.

The four ponds were interconnected at their base. This linkage created a single hydraulic system, with a uniform water level within all the units. Therefore, it became possible to recharge the system of pools from a single feeder point. This water entry was apparently located in the S/E corner, of the S/E pond, at the situation of a natural boulder that was part of its side embankment. The boulder was probably built up with brick to form a water inlet chamber and it received two water lines from different directions of the garden.

Fig 4.12 Water inlets,Garden No 1, Sigiriya
Source– Ancient Ceylon, 1990

The conduit that came from the Southern vicinity of the Water Garden area appeared to convey water from a top up storage cistern outside the formal central garden. The second conduit appeared to be an extention of the line from the Sigiriya Wewa. The boulder base of the inlet chamber had a drain grooved into it and probably extended itself as a spout into the S/E pond.

The bath complex drained out at the base, along the Western side of the N/W and S/W pools.

Instead of a single outlet, each of these pools contained several small openings. The reduced size and increased number of these outlets had a direct bearing on the design of the sluce gate. Less mechanical effort was required to operate the smaller control valves. This would therefore, suggest a very simple, sluice mechanism that was in constant use. Thus depending on the extent of water purification required in the pool, the rate of water change could have been varied, by regulating the sluice gate at the outlet and balancing the inflow at the supply point.

The water outlets from the pool merged into a singled discharge conduit that was shared by several other systems of the upper garden areas. However, back flow contamination was prevented by ensuring that the connection was to a point on the downstream of the discharge line and outside the wall of the pool. The common outflow conduit finally ran into the moat at a low elevation.

GARDEN NO. 2 (Figure 4.11)

Most of the known special water display features of the Western Sigiriya precinct are located in the area identified as Garden No. 2, (Fig.) which lies well below the 200 feet height reference of the site. A positive water pressure head was therefore, established between these display hydraulic features and the supply reservoirs located at the 200 feet contour elevation.

The continuous operation of the display system may have been ensured, by maintaining these storage pools at full capacity. This could be made possible by connecting the pools to the ring-main water circuit of the Sigiriya Wewa, that, probably ran along the 200 feet contour line. The water consumed in this display system was thus automatically replenished with the water from the Sigiriya Wewa, supplied through the storage pools. Hence this system of interconnected pools effectively formed a battery of storage reservoirs that were never empty, since they were continuously recharged with water from the Sigira Wewa. So long as there was a sufficient quantity of water in the storage pools, the system continued to function, causing the bubbling fountains and cascading streams to remain activated.

Fig 4.13 Fountains,Garden No 2 , Sigiriya
Source– Ancient Ceylon, 1990

Located midway within the garden area is an apparent hub of underground water conduits and complex sluice gate arrangement. Hydraulic manipulation at this point could have regulated or altered the water flow within the display features of the garden. This sluice gate facility probably gave a flexibility to the operational process of the display hydraulics, and was a clearly apparent means to sustain uninterrupted flow. It may well suggest the importance of these hydraulic features, in the overall landscape concept of the garden area.

The open display nature of the hydraulic system created considerable a silt load and water contamination. Therefore, elaborate measures were adopted to separate the used water from the fresh supplies in the other garden areas of the precinct. The trace of the underground conduits may suggest that at the end of its gravity flow the expended water in the display system was isolated and shunted into collection conduits that passed under the lower garden areas to finally discharge into the moat.

The path of the bypass conduit carrying the contaminated water was ducted under the base of the bathing ponds in Garden No. 1 to effect a straight and economical run. The plastered rendering on the paved base of the pond ensured complete isolation of the waster water system.

In order to economize on the quantity of conduiting, the waster wate lines of the separate hydraulic systems were often mergad to form common lines. The bypass conduit from Garden No. 2 therefore combined with the discharge line from the bathing pools in Garden No. 1 and formed a single common outflow duct before it reached the discharge point in the moat.

GARDEN NO.3 (Figure 4.11)

The bathing pool commonly identified at the "Octagonal Pont" is the most significant hydraulic feature of this garden area. It was probably an exclusive bathing facility used only by the King and his immediate Royal Court.

The Royal bath would have naturally required nothing less than the purest water. This need was supplied by means of an elaborate hydraulic system that could be conjectured in terms of the overall irrigation pattern of the precinct.

Before use, on these occasions, the pool was probably flushed out by draining the water through a conduit, into the immediately adjacent moat of the N/W Summer Palace. Thereafter the pool was likely to have been refilled with fresh water supplied from the Sigiriya Wewa by tapping the Ring-Main conduit that ran along the 200 feet contour (Ref. Previously described supply system). The refilling process may have been quickened by another supply, provided from the battery of cisterns located in the upper regions of the Western terrace garden area.

Since the "Octagonal Pond" was an integral part of the overall site drainage system (Ref. Previously drainage system) overflow from the pond may have supplemented the water supply required to activate the display hydraulics in the lower garden areas of the precinct.

Prolonged drought periods may have dried up the water supply to the pond from the upper regions of the terrace garden area. However, the Octagonal Pond" always had the possibility of being serviced with a water supply from the Sigiriya Wewa. Therefore, it could have continued to function as a perennial fresh water bathing facility in the upper precinct o the Sigiriya Garden.

MINIATURE WATER GARDEN (Fig 4.11)

A concentration of display hydraulics, limited to a constricted section along the extreme edge of the Western Water Garden precinct (Fig. 4.11) suggest the view that this area was designed as a Miniature Water Garden.

Primarily consisting of shallow reflecting pools, the entire hydraulic display showed evidence of a conscious attempt to reduce design scale. Thus making it feasible to Work the display, system with a relatively small volume of water, continuously, even during the dry season of the year.

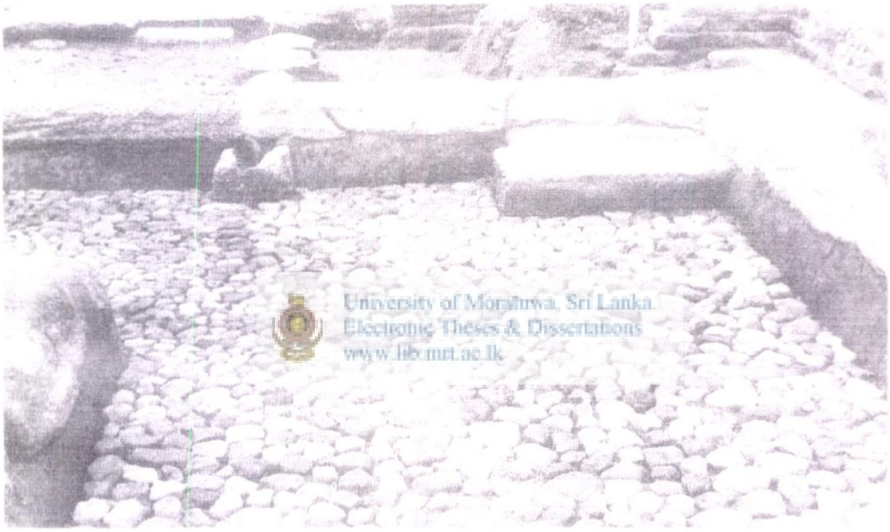

Fig 4.14 Cobbled water course, Miniature water garden, Sigiriya
Source– Ancient Ceylon, 1990

Storage cisterns located at the South end of the Miniature Water Gardens area probably received and collected roof drainage through an apparent system of impluvia. This quantity of stored water wold have been supplemented from the Sigiri Wewa through a conduit that crossed the South side of the precinct.

The excess rain water run-off and the final outflow from the display system passed into the drop manhole located at the North end of the garden, to enter the main discharge conduit from the upper Water Garden area. To slow down silting, the manhole was covered with a stone slab and perforated with holes to permit the water. Since the Manhole cover was of limestone material it would be possible to surmise that this stone slab was part of an overall display feature, at the Northern part of the Miniature Garden.

The display hydraulic features at the North end of the garden contained built-in silt trap chambers. This would suggest that the water flow in the entire hydraulic system was propelled by gravity in a South to North direction.

4.4.4 HYDRAULICS OF THE PALACE COMPLEX

The Royal Palace complex located on the summit of the Sigiriya Rock had its own independent source of collected rain water, stored at the top of the rock in a central large reservoir and several smaller cisterns. This was the most practical storage system at that elevation, 600 feet above the surrounding flat plane.

The rainwater collected by precipitation and stored in the central reservoir at the summit, thus became the primary domestic water source and directly determined the strength of the population in residence at the Palace Complex. This number could therefore be logically surmised on the basis of the estimated volume of the storage supply.

At the altitude of the summit a strong wind was always prevalent. The unrestricted blowing across the surface area of the reservoir, would have aerated the water in the tanlk and created a natural water purification process. Therefore, the supply in the storage reservoir may be assumed to have remained fresh throughout the year, but the winds would also have increased evaporated water loss.

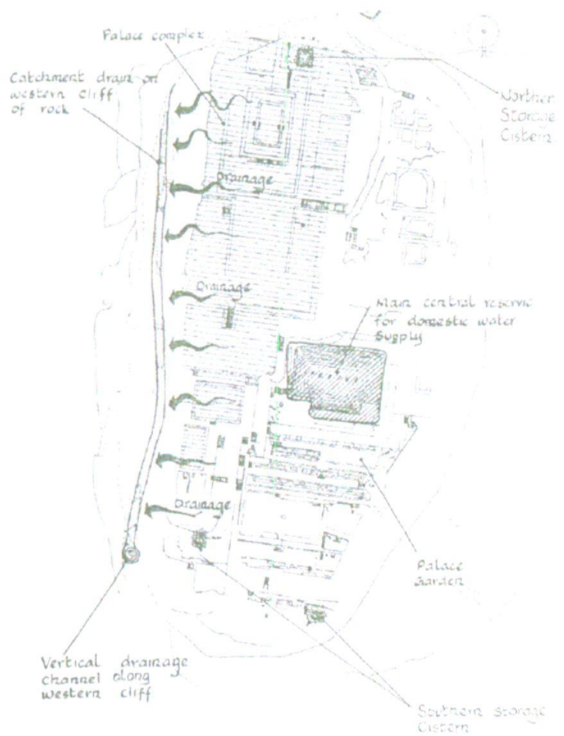

Fig 4.15 Hydraulics of the palace complex, Sigiriya
Source– Ancient Ceylon, 1990

Fig 4.16 Reservoir at Summit

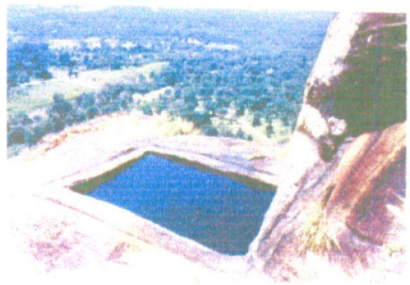

Fig 4.Storage cisterns

A gravity hydraulic system may have been in operation to distribute the water through the underground conduits. The general slope of the summit was in the N/S direction influencing the flow southward. It is therefore, surmised that the plan of the Palace would have contained the living quarters at the higher north end and the service quarters at the lower south end. To permit easy irrigation, the Palace gardens were also terraced down the south slope of the summit.

4.4.5 HYDRAULICS OF THE MOATS

- **INNER MOAT**

The inner moat encircles the entire Sigiriya Complex, in a course that runs along the lowest contour o the slope skirting the Sigiriya Rock.

The hydraulics of the moat made it essentially function as the final discharge sump, for all the Water Systems within the citadel.

Several overflow connections would have linked the moat with the Sigiriya Oya in the downward direction of its flow. This allowed the excess water received in the moat to be channelled into the overall irrigation network of the Sigiriya area. Except for this excess overflow arrangement, the moat was a closed hydraulic system that was designed to conserve and retain a greater part of the collected discharge.

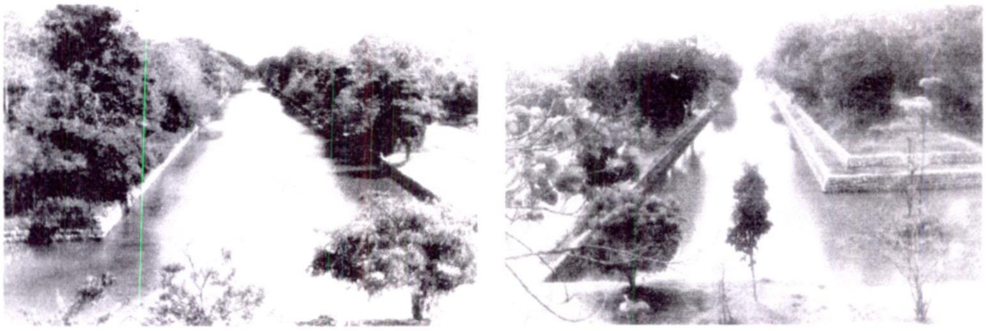

Fig 4.18 Inner moat at Sigiriya in the rainy season

The conduits conveying the collected outflow from the various systems within the precinct were designed to enter the moat at an intermediate point, in its inner embankment, below the surface of the water contained in the moat. This hydraulic feature in the system was intended to control the velocity of the water outflow into the moat and thus protected the embankment from erosion.

"The site topography in relation to the invert elevation of the moat may also suggest the possibility of the moat providing a water supply into the trenches that surround the Summer Palace Island. A single conduit, laid in a N/S direction from the moat may have linked the trenches with the closed hydraulic system of the moat. This connection would have caused the moat water to flow into the trenches and fill to a level that established a static water equilibrium with the moat."[1]

The hydraulics of the moat probably had some type of provision that allowed the closed system to be breached through a sluice gate and irrigated by the Sigiriya Wewa. This facility guaranteed a water supply to the moat at a time of drought. A critical requirement of its fortification function was thereby satisfied.

1 Ellapola C. Ancient Ceylon No. 11 Vol. 5 Dep. Acheaology Colombo 1990.

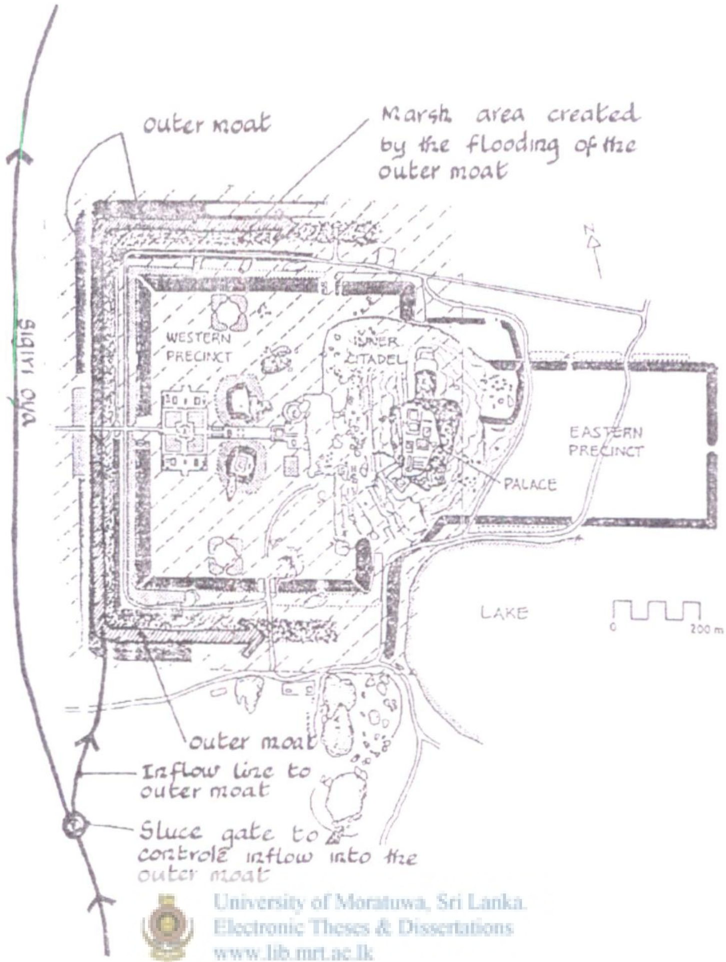

Fig 4.19 Hydraulics of the Inner moat
Source– Ancient Ceylon, 1990

■OUTER MOAT

The Outer Moat was probably irrigated from the Sigiri Oya by an upstream connection that was probably controlled with a sluice gate. Essentially the Outer Moat served as an open channel to conduct the water of the Sigir Oya around the outer boundary of the Western precinct.

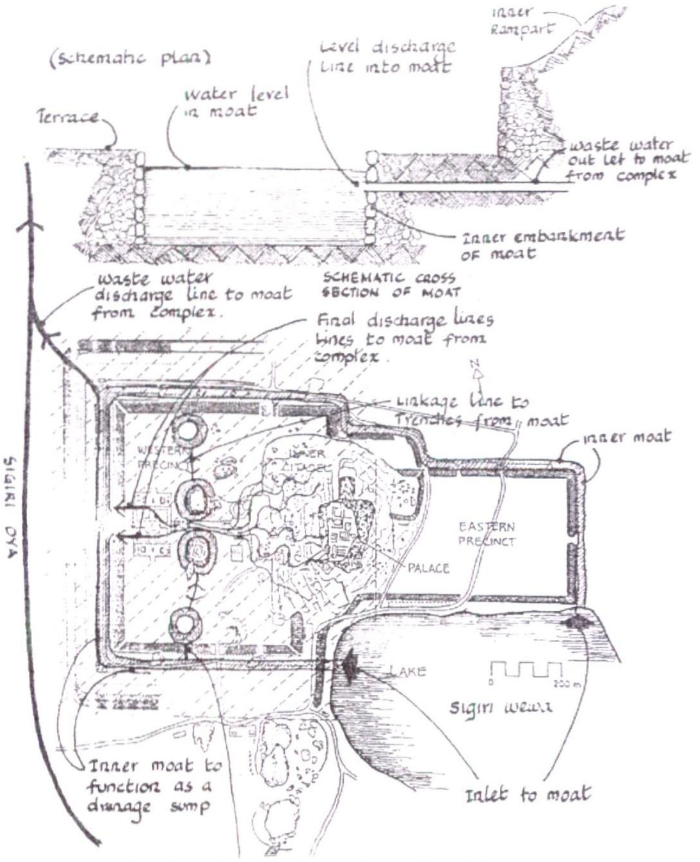

Fig 4.20 Hydraulics of the outer moat
Source– Ancient Ceylon, 1990

When the citadel was under a threat of attack the Upstream sluice gate way could have been operated to divert the water into the outer moat, which in turn flooded the vicinity of its embankments. Thus creating a surrounding marshy area that became the first line of defence for the citadel during an enemy invasion. The hydraulics of the outer moat were therefore, expected to work only on an intermittent basis. This flexibility of operation served to conserve the water in the Sigiriya Oya for more profitable alternate everyday use.

4.5 ENGINEERING ANALYSIS OF WATER POTENTIAL IN SIGIRIYA GARDEN

According to the proceeding conjectural hydraulics system the major water supply source to the garden is the Sigiriya Wewa. The fountains in the water garden, (Garden No. – 2) are only the functional hydraulic element. The operational ability of the fountains re depends on the, hydraulic potential of the Sigiriya Wewa. The relationship between hydraulic potential and operational ability of the fountains can be properly justified by doing hydraulic research.

Research Objectives : To determine the hydraulic potential and study the relation between "regional rainfall" and fountains operating capacity.

Methodology :

- Assume major hydraulic potential path.
- Determine the hydraulic gradient using velocity meters and pressure meters.
- Draw the hydraulic gradient curve during the year. (dry and rainy season)
- Analyzed past data at maximum operating capacity.

Eg :- 1995 Jan – Height of the water jet. 400mm.
2000 Jan – Height of the water jet. 300mm.
2001 Jan – Height of the water jet. 230mm.
2003 Jan – Height of the water jet. 275mm.

Data Collection : Two types of data are used to analyze.

(a) Past recorded data
(b) Research data collecting

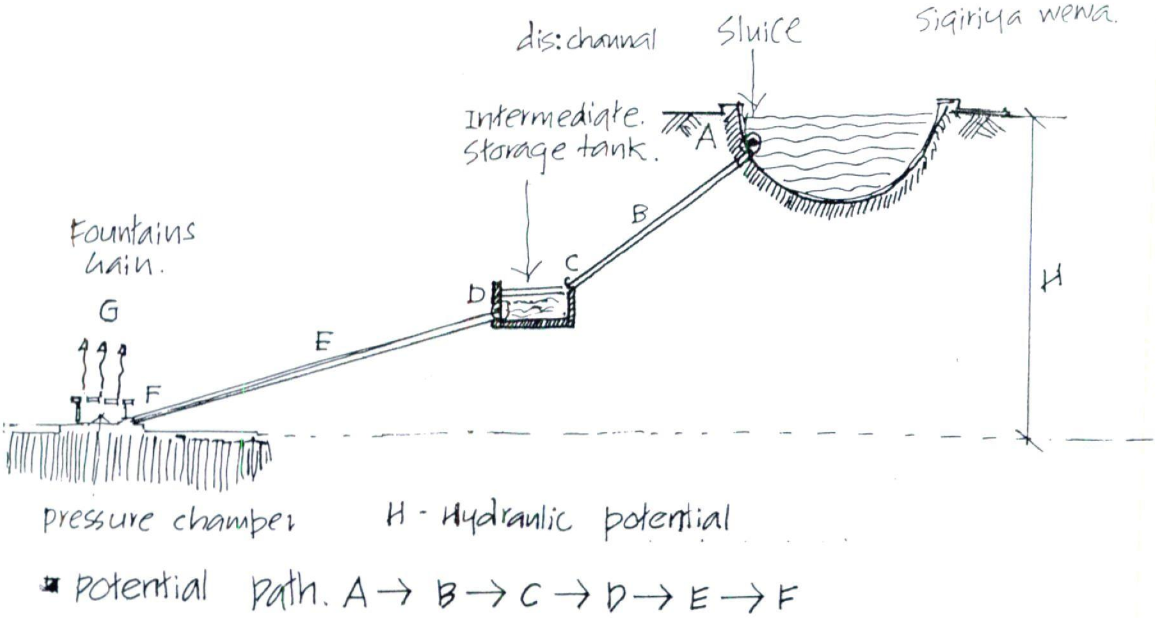

Fig. 4.21 The diagrammatic potential path Sigiriya Wewa to pressure chamber.

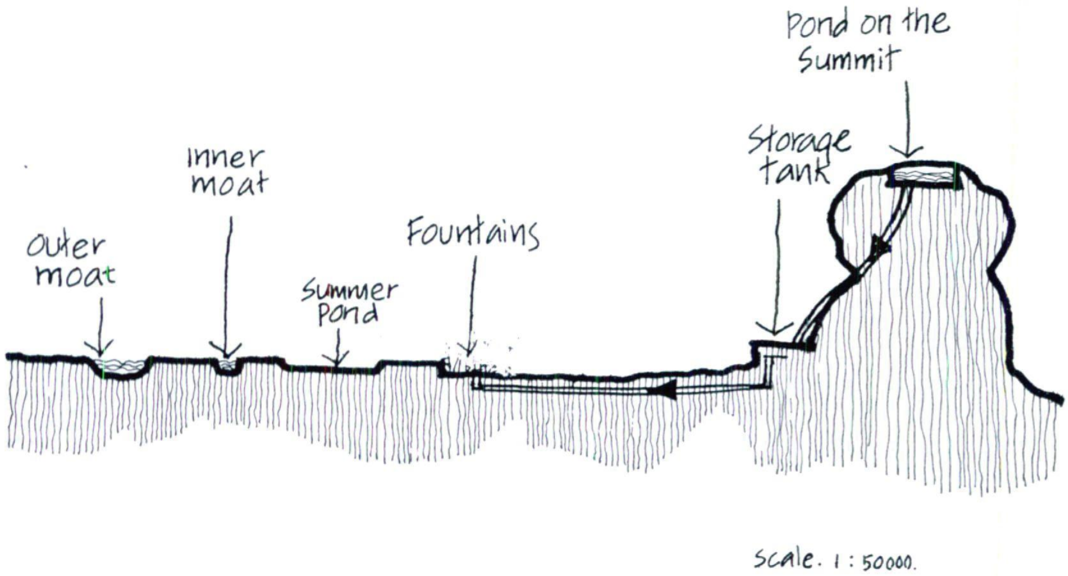

Fig. 4.21 Sectional diagrams of conjectural potential path

Conclusions

CONCLUSIONS

Wisdom of "**water and people**"

Ever since your saplings have thrived, In every village and city temple

Leaving a green meshed verdure, The landmark of vibrant Bodhi culture.

The Methuselah of millenniums

A witness to glories and grandeur of our civilization, Saw disasters, bloody encounters

Leaving the majestic city, It ruins and hambles. A privy to many secrets

That none can decipher or unravel.

Amarasekara A.

"The humans are first seen to live within the enclosures of nature, the man himself subsequently groomed as a habitat with such elegance. Stored water had been the true-life line of vegetative sustenance. The lush trees the product of a sun-kissed soil, the toil of a worn-out resource, mainly, the man. This continuous battle of man with sun, rain and earth has produced the subtle harmonies by combining trees and water.[2]

1. Amarasekara, Ceylon Daily News, 1990.02.15, Anil Publications, Colombo
2. Prof. Nimal De. Silva, Landscape Traditions of Sri Lanka

The Sigiriya frescoes like the poems on the Mirror Wall are undoubtedly an expression concerning the landscape. They interest us not like as beautiful terracotta sculptures but also as unique historical documents, supplementing the insights. I gain from the poems glimpses into the society that created the hydraulics of Sigiriya and its landscape sensibilities.

"Their bodies' radiance, Like the moon
Wanders in the cool wind, The song of Lord kital
Sweet girl, Standing on the mountain,Your teeth are like jewels,
Lighting the lotus of your eyes, Talk to me gently of your heart" 1

On the hand is a classic example of a piece of formal landscape architecture in the traditional Sri Lankan profile. As a blend of artificial and natural landscape features the basic layout is formal .here again water is used to arouse the senses. One experiences various sensation while walking over dry, damp and water impregnated sand.
The palace & garden complex is so uniquely well-preserved for its great age, and so distinction in its use of water that I would like to recommend that in addition to its World Heritage Site designation, it should also be designated as a living museum of Sri Lankan hydraulic techniques. Such a designation would probably arouse opposition from archaeologists who seek only to conserve Sigiriya as an archaeological site & without restorations or reconstructions. But it may be argued that such restorations can be carried out in working models & not on the excavated fabric, and that a full working models of all the hydraulics could become the centre piece of a new and enlarged museum at Sigiriya.

1. Paranavithana S., Sigiri graffit 1970 vol2p70v115

The archaeological evidence discovered so far conclusively suggest the view that the aspects of hydraulic engineering was an important element of the overall design at Sigiriya, that is essential to express these hydraulic features to a level of high visibility. What ever, methods may be adopted towards this end it would be apparent from this dissertation that the key to the solution lies in restoring the original source of water to function the Sigiriya water garden. It is there for necessary to conserve the Sigiriya wewa at least to the extent of its present boundaries.

If the level of water in the Sigiriya wewa would be maintained through out the year above the 200m contour height, an adequate volume will be available to supply and activate the water gardens of the Sigiriya complex. Undoubtedly it would regenerate the dust free cool environment which was surely the original design intent of the ancient Sigiriya Garden.

In addition the economic potential of the villages of surrounding Sigiriya settlement areas of Alakola wewa, Polaththawa, Sigiriya, Kibissa, Pidurangala can be improved by developing their cultivation capacity.

Other my important proposal is conversion of Sigiriya garden to the miniature hydraulic museum, by keeping the landscape and architectural beauty.

Detailed identification of underground water paths is very difficult. I suggest use of the method of hydro isotopes. This I tried to initiate, but I was unable to carry out in the available time. I recommend that it be under taken in a future research program, to allow a fuller and more complete understanding of Sigiriya's marvelous waterworks.

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KINGS OF ANURADHAPURA AND THEIR DEVELOPMENT WORKS

NO.& KING	PERIOD	RESERVOIRS		IRRIGATION		MONASTERY		MONASTIC		CIVIL WORKS	
		NEW	OLD	NEW	OLD	NEW	OLD	NEW	OLD	NEW	OLD
1.VIJAYA	483-445									06	
2.PANDUWASDEVA	444-414	01							03		
3.ABHAYA	414-394										
4.TISSA	394-377										
5.PANDUKABHAYA	377-307	01	01					14		18	
6.MUTASHIVA	307-247									01	
7.DEVANAM PIYATISSA	247-207	01				09		94		01	
8.ABI ANURADHI	207-197										
9.MAHASIVA	197-187			01		01					
10.SURA TISSA	187-177					500					
11.SENA-Tamil	177-										
12.GUTTIKA-Tamil	-155										
13.ASELA	155-145										
14.ELARA-Tamil	145-101								01		
15.DUTU GEMUNU	101- 77					99		04			
16.SADDHATISSA	77- 59					09	01	04		01	
17.THULLATHANAKA	59										
18.LAJJA TISSA	59- 50					02		07		01	
19.KHALLATA NAGA	50- 43					33		01			
20.WATTA GAMANI	43- 17	01				09		01			
21-25 TAMIL RULE	43- 29										
26.GAMANI TISSA	17- 03										
27.MAHA NAGA	03- 09					06					
28.KUDA TISSA	09- 12			01							
29.ANULA	12- 16										
30.KALAKANNI TISSA	16- 38	02		01		02		03		03	
31.BHATIKA ABHAYA	38- 66							03	01	02	
32.MAHADATTA MAHANAGA	67- 79					05		04		05	
33.AMANDA GAMANI	79- 89					02		05			
34.KANJANU TISSA	89- 92										
35.CHULABHAYA	92- 93					01					
36.SIVALI	93										
37.ILA NAGA	93-102	02						01			
38.DAMILA DEVI	103-112	01									
39.YASALALAKA TISSA	112-120										
40.SUBHA	120-126					02		03			
41.WASABHA	127-171	11		15		03		23	02	06	
42.MAHAMATTA	172-174					01					
43.GAJABAHUKA GAMANAI	174-196	01				03		06	01	01	
44.MAHALLAKA NAGA	196-202					07					
45.BHATIKA TISSA	203-227	02				02		02			

ANNEXURE

CHART (CONTINUE)

NO.& KING	PERIOD	RESERVOIRS NEW	RESERVOIRS OLD	IRRIGATION NEW	IRRIGATION OLD	MONASTERY NEW	MONASTERY OLD	MONASTIC NEW	MONASTIC OLD	CIVIL WORKS NEW	CIVIL WORKS OLD
46.KANITTA TISSA	227-245					09		08	01	01	
47.CHULA NAGA	246-248										
48.KHUDA NAGA	248-249										01
49.SIRI NAGA	249-268							01	05		
50.VOHARIKA TISSA	269-291							20			
51.ABHAYA NAGA	291-299							02			
52.SIRI NAGA II	300-302							02	01		
53.VIJAYA KUMARA	302-303										
54.SAMGHATISSA	303-307							02	01		
55.SIRI SAMGABODHI	307-309							01			
56.GOTHABAYA	309-322					01		10	07	06	
57.JETTHATISSA	323-333	01				01		03	01		
58.MAHASENA	334-362	16		01		14		04	02		
59.SIRI MEGHAVANNA	362-	03				01		24	04	01	
60.JETTHATISSA II	-										
61.BUDDHADASA	-	02				01		01		06	
62.UPATISSA	-409	06				01		03			
63.MAHANAMA	409-431					01		03	03	01	
64.SOTTHISENA	431										
65.CHATTAGYAHAKA	431-432										
66.MITTASENA	432-433							03			
67.PANDU	433-										
68.PARINDA	-										
69.KHUDA PARINDA	-										
70.TOROTARA	-										
71.DATHIYA	-										
72.PITHIYA	-460										
73.DHATUSENA	460-478	21		18		37	02	07	03	02	
74.KASSAPA I	478-496					02	01	02		03	
75.MOGGALLANA I	496-513					02		01			
76.KUMARA DHATUSENA	513-522						01				
77.KITTISENA	522										
78.SIVA	522										
79.UPATISSA II	522-524										
80.SILAKALA	524-537										
81.DATHAPABHUTI I	537										
82.MOGGALLANA II	537-556	03		01							
83.KITTI SIRIMEGHA	556										
84.MAHA NAGA	556-559			01			02	01	03		
LAMANI SINGANA	559-568										
85.AGGABODHI I	568-601	03		04		08		05	01		
86.AGGABODHI II	601-611	13		01		05		07	02		
87.SAMGATISSA	611										

ANNEXURE

CHART (CONTINUE)

NO.& KING	PERIOD	RESERVOIRS NEW	RESERVOIRS OLD	IRRIGATION NEW	IRRIGATION OLD	MONASTERY NEW	MONASTERY OLD	MONASTIC NEW	MONASTIC OLD	CIVIL WORKS NEW	CIVIL WORKS OLD
88.MOGGALLANA III	611-617					04					
89.SILA MEGHAVANNA	617-626								03		
90.AGGABODHI III	626-										
91.JETTATISSA III	-										
AGGABODHI IV	-					01					
92.DATHOPATISSA I	-641					01					
93.KASSAPA II	641-650										
94.DAPPULA I	650										
95.HATTADATTA	650-658					01					
96.AGGABODHI IV	658-674					10					
97.DATTA	674-676					01					
98.HATTADATTA	676							01			
99.MAHAVAMMA	676-711					02		02		02	
100.AGGABODHI V	711-717		01			04		04	03		
101.KASSAPA III	717-724					05		01			
102.MAHINDA I	724-727					01		01			
103.AGGABODHI VI	727-766					03		03			
104.AGGABODHI VII	766-772					02		01			
105.MAHINDA II	772-792	01			01	03		02	04		
106.UDAYA I	792-797			01		02	01	10	05	08	
107.MAHINDA III	797-801						01				
108.AGGABODHI VIII	801-812					02					
109.DAPPULA II	812-828					01		02	04		
110.AGGABODHI IX	828-831										
111.SENA I	831-851					05		11	02	01	
112.SENA II	851-885			04		03		03	02	01	01
113.UDAYA II	885-896			03	01			02	01	02	01
114.KASSAPA IV	896-913					07		13	02	02	
115.KASSAPA V	913-923					03	01	03	01	02	
116.DAPPULA III	923										
117.DAPPULA IV	923-934							01			
118.UDAYA III	934-937										
119.SENA III	937-945				06			15	01	01	
120.UDAYA IV	945-953							01	01		
121.SENA IV	953-956										
122.MAHINDA IV	956-972			03		06		06	08	03	
123.SENA V	972-981										
124.MAHINDA V	981-993									01	

NOTE:
This chart based on the chronological order and the names of the kings as given in Mahavamsa (Guruge) and Culavamsa (Geiger) translation.

ANNEXURE