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Application of Rain Water Harvesting in Provincial Building Complex at New Town, Ratnapura.

Jayantha Gunatilake

1. Introduction

Adequate freshwater supply is the most important precondition for sustaining human life and for achieving sustainable development. With the increase of human population, demand of freshwater particularly in the urban areas increased. In light of this, the Sri Lankan government has announced a national target: "Safe drinking water for all by 2005" to set as follows.

1 Increase coverage to provide access to safe drinking water to 85% of the population by the year 2010 at an affordable price.

2 To achieve an adequate level of pipe borne water supply in urban area.

3 To meet the demand of 24 hour water supply for industry and service sectors.

In the face of the shortage of capital and as well as the need to improve the economic efficiency, water supply and sanitation decision-makers face increasing challenges to identify and secure water resources to meet above targets. Hence it is essential to identify strategies to introduce alternative water sources such as rainwater etc. and water saving devices, in planning and mobilization of water resources.

This paper describes the challenges face during design, construction and operation of the rain water harvesting system in new building complex of the Sabaragamuwa Provincial Council and highlights number of key lessons that can be adopted and replicated elsewhere in similar developments and resource management intervention.

2. Project Description

The six-storied building complex of the Sabaragamuwa Provincial Council is located 3 kilometers away from the old town of Ratnapura on the Colombo-Ratnapura Road. This building complex consists of six small ministry offices and general service offices like Post Office, Bank and Information Centers. (Please refer Fig. 1)

The first stage of the new building of the Sabaragamuwa Provincial Council complex was completed in 2002/2005 in a 2-acre land acquired from the Urban Development Authority. The roof areas of the existing building are 19mx44m and 30mx39m in size. The collection of rainwater from the roof, are directly fed into the storage tanks (2 nos.) placed on the sixth floor roof, which have a capacity of 3.3mx5mx1.2m (22m^3) each. This storage water will be use for gardening and toilet flushing purposes. Additional plastic tanks placed on the concrete tank to storage drinking water etc. An underground well was designed for 40m^3 water collection during drought. A sump tank was also designed to store water up to a capacity of 60m^3 within these premises. Two three phase motors were installed to pump water to the highest level. (Please refer Fig. 2)

Three-roof tops that contribute to drain water into the garden premises were identified using the drainage pattern from contour maps. (Please refer Fig. 3) The outer periphery and its watershed boundaries were first identified using storm drainage maps. These areas were further confirmed and revised by site inspection after confirmation of the main boundaries coupled watersheds drainage network and outlets. The watershed area' length of the longest stream and land use pattern were calculated for the use in runoff calculations. The storm water drainage system collects the water from the respective roof tops and release them to the garden under gravity. Area, lengths of different storm water stream segments, and elevations pertaining to each stream segment were extracted from the maps.

3. Design Calculations, Assumption & data

Assessment of the capacity of the water storage tank was done according to following calculations.

Eng. Jayantha Gunatilake B.Sc(Eng). C.Eng. FIE(SL)
Director (Buildings) Sabaragamuwa Provincial Council

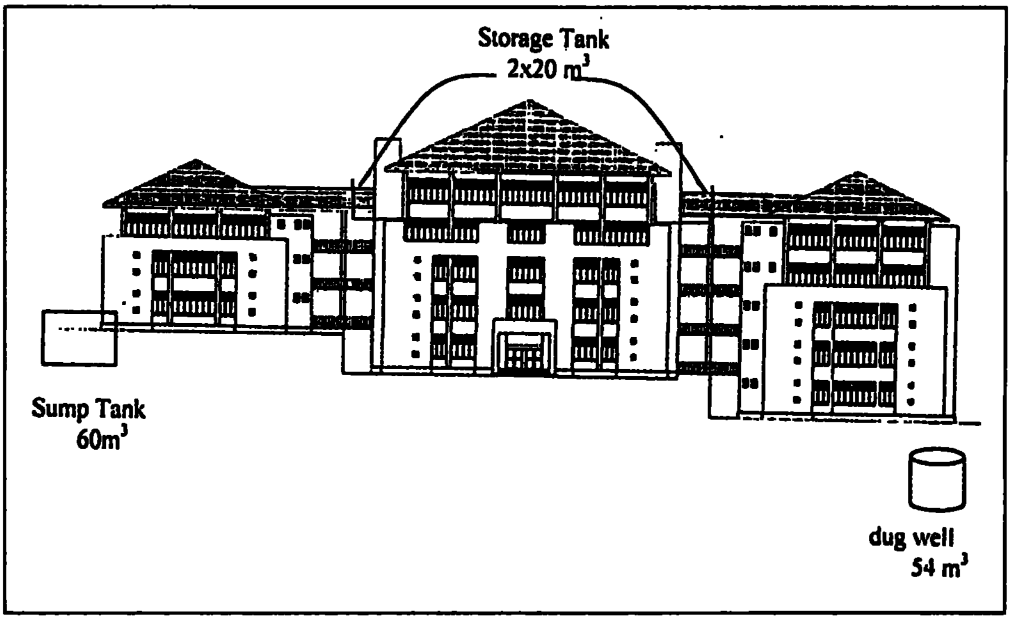


Figure 1 :

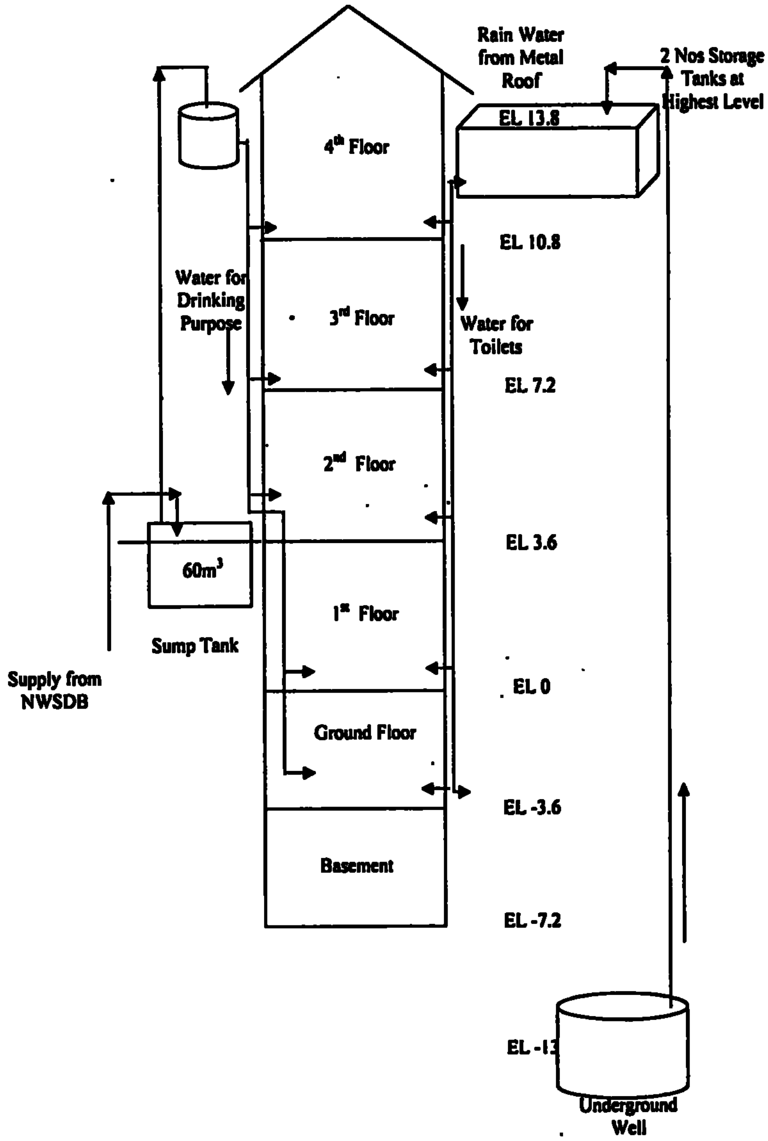
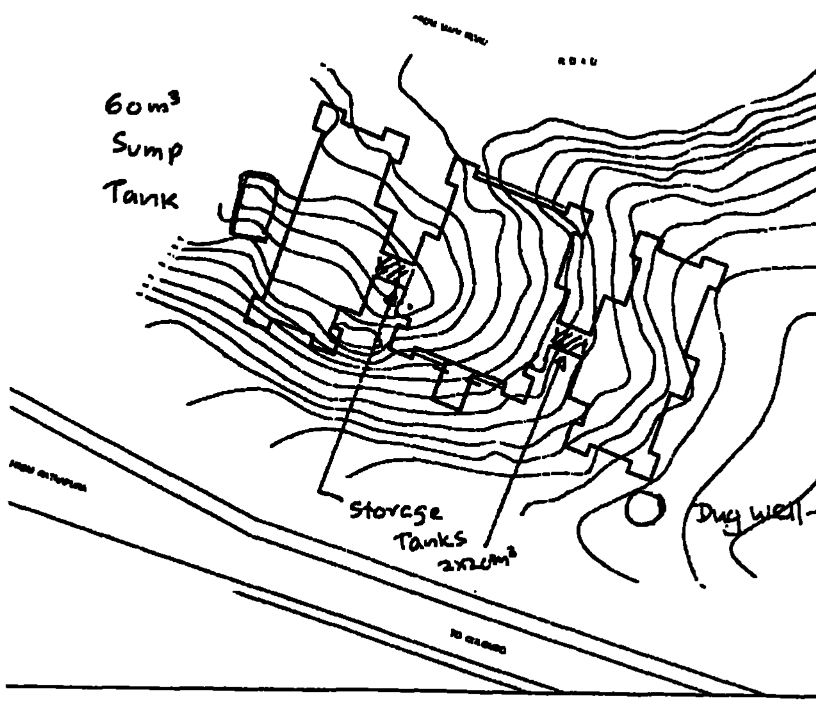


Figure 2 : Flow Diagram of RWH system at Sabaragamuwa Provincial Council



Lay Out Plan

Figure 3 : New Office Building Complex
Sabaragamuwa Provincial Council - New Town - Ratnapura

(a)	Number of office workers within the Sabaragamuwa Provincial Council Office	400 Nos.
(b)	Number of Visitors per day	200 Nos
(c)	The run-off coefficient	0.5
(d)	Height of the water head from sump pump to overhead tank	15 meters
(e)	Head losses	2 meters
(f)	Filter efficiency	0.9
(g)	Longest average dry period	15 days

Rain Water Yield (Liters per Year)	=	Roof Area (m^2)	x	Annual rainfall (mm)	x	run-off coefficients	x	Filter efficiency
	=	2842	x	2900	x	0.5	x	0.9
	=	3708 m^3						

To calculate the required tank size	=	5% of 3708 m^3
(A proven and workable rule of thumb)	=	18.5 m^3
Minimum storage requirement	=	600 x 10 x 15 = 90 m^3

Spread calculation for sizing the storage tank

1	2	3	4	5	6	7
Month	Rainfall (mm)	RWH (m^3)	Cumu. RWH (m^3)	Demand (m^3)	Cumu. Demand (m^3)	Difference
JAN	164.24	9.8	9.8	15.325	15.325	-5.525
FEB	221.84	11.1	20.9	15.325	30.650	-9.75
MAR	209.60	10.5	31.4	15.325	45.975	-14.57
APR	376.40	19.8	51.2	15.325	61.300	-10.10
MAY	493.80	24.6	75.8	15.325	76.625	-0.825
JUNE	350.80	17.5	93.3	15.325	91.950	1.350
JULY	257.00	12.8	106.1	15.325	107.275	-1.175
AUG	239.80	11.9	118.0	15.325	122.600	-4.600
SEP	335.20	16.8	134.8	15.325	137.925	-3.125
OCT	428.0	21.4	156.2	15.325	153.25	2.950
NOV	361.60	18.1	174.3	15.325	168.575	5.725
DEC	192.20	9.6	183.9	15.325	183.900	0.000

Rain Water Harvesting Project Cost Involved In addition to the existing Water Supply System

Two inches water supply pvc pipe length (600 type)

including brackets & labours	Rs	6,000.00
Brass gate valve cost	Rs	1,500.00
Filter materials fixed (Mesh etc.)	Rs	500.00
End cap and diversion system	Rs	2,000.00
Plastic tanks for storage at ground level	Rs	20,000.00
Total	**Rs**	**30,000.00**

4. Justification of cost effectiveness in relation to Electricity cost for pumping

Assume pump efficiency = 55%

Friction head loss = 2m

Pumping head = 15 m

Total head = 17 m

Energy requirement = 146,757 J=40.77KWh

Cost of Electricity for pumping = 40.77 x 15 RS

= RS. 600.00

Roofs Area = 2842 m^2

Rainfall = 2990 mm/year

Rainwater Available = 8.4 million liters

Rainwater Harvesting = 4.2 million liters

Investment Cost = Rs.1.2 million

Saving from water harvested (RS) = Rs 120,000 per year

Water Saving Cost-Sabaragamuwa Provincial Building

Consumption Percentage Before and after RHW

	Before %	After %
1. Drinking and Dishwashing	20	20
2. Maintenance leakage and cloth washing	20	15
3. Personal washing	15	15
4. Toilet flushing	35	0
5. Car washing	5	0
6. Gardening	5	0

Total water requirement per day =

400 nos x 45 L + 200 nos x10 L = 20 m^3

Monthly water saving Amount

= 10 m^3 x 24 days x Rs. 42 = Rs. 10,080.00

Saving from water harvested

= Rs. 120,960.00

Computer model

There are several computer-based programmes for calculating tank size quite accurately. These are available at www.eng.warwick.ac.uk/DTU/rwh/model/index.html

Input data for above computer model

Location	Sabaragamuwa Provincial Council Office
Roof area	2842 m^2
Nominal demand	180,000 liters
Mean daily runoff	22,676 Liters
Water management strategy	Tank Level

Tank Volume (Liters)	20,000	113,400	453,500	1,8814,000
Reliability	46%	84%	98%	100%
Satisfaction	70%	91%	99%	100%
Efficiency	62%	86%	97%	99%

Note

1. Reliability is the fraction of days the total demand will be met by the system.
2. Satisfaction is the fraction of the total water demand that can be met by the stem
3. Efficiency is the fraction of the runoff from the roof captured by the system.
4 The comparison tank volumes are based on the average daily roof runoff multiplied by 5 days, 20 days and 80 days respectively.
5 The calculated nominal demand is set at the mean daily runoff.

5. Operation and maintenance of the Rain Water Harvesting System (RWH)

The Storage tanks were placed on the stair cases located on either side of the main building. (Please refer Fig. 1) Installation requirements for the system can be listed as below.

(a) Rain water collection from Zn-Al (Amano) sheets metal roof through guttering up to the high elevation concrete storage tank. (2x22m^3)
(b) Over flow arrangements and separate water connection for toilets and individual washing purposes.
(c) Separation of water Board Supply from Rain water system and pump systems from sump pump during a possible drought.
(d) Filtering arrangement placed at the in let and out let of rainwater source using meshes.
(e) Manual "first flush" system

Precautionary measures to ensure quality and smooth maintenance and operation process are as follows;

1 Minimized bacterial contamination by keeping the roof top surface and drain clean. Periodical maintenance system adopted.
2 Check and clean the storage tank periodically using a chlorine solution (followed by thorough rinsing)
3 Inspect the gutters and down pipes when it rains so that leaks can easily be detected. Routing maintenance work as detailed.
4 Preparation of guide lines to decide maintenance work
5 Identifying authorities, who should take relevant actions to prevent encroachment & human activities.
6 To allow for the movement of maintenance personnel, equipment and materials during maintenance operation.
7 Dumping of garbage or any other to the building premises is highly prohibited.

6. Problem faced During Implementation and how they were overcome

Designing this project was done by the Engineering Services Team of Sabaragamuwa Provincial Council, while the Central Engineering Consultancy Bureau (CECB) carried out the implementation. The proposal for RWH was presented and discussed at a PC's progress review meeting. The Governor and Chief Secretary gave a special recommendation to the project because the users had been motivated to use rainwater.

Responsibility of the Sabaragamuwa Provincial Council's Engineering Services Team were:

a) Provision of professional expertise for RWH development,

b) Preparation of work plans for the development at the construction stage
c) Recommendation of projects for funding
d) Project review, monitoring and evaluation.

Problems faced by the team are summarized as below.

1 Lack of consideration by the management for new technique and deviate from the traditional methods.
2 Lack of experience site engineers and other technical staff and lack of facilities to train the workers of all classes.
3 Difficulty of retaining experienced workers because of the low salaries and lack of site co-ordination
4 Difficulties in making the workers understand the rainwater harvesting method and ignorance by the site technical staff.
5 Although the contractor had knowledge in Rain Water Harvesting (RWH), they had no knowledge in obtaining support from other .NGO and government agencies.
6 No government agency capable of understanding the RWH at the local government level
7 Less attention by most government Departments and politicians towards the urban needs because of the existing water board supply.

Following actions were taken to overcome the above problems.

1 Organizing awareness Prograni with the help of Lanka Rain Water Harvesting Forum (LRWHF) at Sabaragamuwa Provincial Council.
2 Organizing Training at University of Moratuwa and Institution Construction Training and Development (ICTAD) provided to the Engineers and workers at all levels.

It was emphasized during the training that it is logical to look at rain (the primary source of almost all waters) as one of the city's water source. Urban areas are usually confronted with issues pertaining to water such as:

1 Lack of full water from traditional sources (therefore rainwater as a supplementary source)
2 Urban flooding (therefore rainwater harvesting as a flood mitigation measure)
3 Depletion of groundwater aquifers (therefore rainwater harvesting as a method of artificial recharge)
4 Disappearance of lakes and natural hydrological courses (therefore rainwater harvesting as a method of restoring these water bodies)

The Engineering Team had discussions with the Owner of the building, to assess their needs. During these discussions, the client expressed deep concern for harnessing rainwater for both domestic consumption and small-scale maintenance work such as landscaping and development work.

7. Advantages and Disadvantages of Rain water Harvesting System

Following general observations were made with regard to RWH systems in operation that are valid in this case study too.

Advantages

(a) It makes financial and ecological sense not to waste pure natural resources available in large quantity on metal roof.
(b) Purchase of water from private and government sector is unreliable in quality and is also expensive. Monthly water bill approximately RS. 10,000.00
(c) It encourages water conservation and self-dependence
(d) Provides water at a point where is needed. The system is operated and managed by the owner. Construction and maintenances are not labor intensive.
(e) Physical and chemical properties of rainwater are superior to those of groundwater or desalinated water especially during flooding.

Disadvantages

(a) Completely dependent upon the frequency and amount of rainfall. There will be shortages during dry spells or prolonged droughts, which can be aggravated by low storage capacities.

(b) Rain water may become contaminated if the storage tanks are not adequately covered and uncovered or poorly covered. Storage tanks can be unsafe for young children. Special room has been made over the sump tank at new town office.

(c) Lack of water treatment may lead to health risks.

(d) Little maintenance to minimize wastage trough broken gutters, drainpipes, leaking storage tanks or outlet taps.

(e) Must adopt some method for increasing the impact of the public information and training programming.

8. Recommendations

Experience and information gathered during the project can be listed as follows which are worthwhile for future reference'

8.1 Short-term Prospects (10-20 years)

The short-term prospects are restricted to ten to twenty years in view of the rapid advances in technology, Internet communication, and the promotion of cooperation between private and public sectors. These prospects are listed as follows:-

1. There are rainwater harvesting development policies in every nation nowadays. In addition, each country will have a set of rainwater harvesting development and operation guidelines for their private and public sectors to follow. Many of the countries have their own electronic listing of hardware and software for rainwater harvesting development and operation. Homepages of each product or service can provide easy access to rainwater harvesting users. In addition, users can make their optimal selection of hardware and services without leaving their house.

2. Hardware that has met safe environmental standards for rainwater harvesting be made available in many cities and towns. Their prices should be affordable and available in different size, shape, and constructional material. Most of these have service lives from fifteen to more than twenty years.

3. Users of rainwater harvesting to form their own rainwater harvesting clubs to help each other in operation and maintenance of their rainwater harvesting systems. Many of these expand their scope to work to community improvement. Modern in-house water treatment hardware helps rainwater-harvesting users to obtain and maintain their drinking water supply at a low cost.

4. Educational institutions can cooperate to offer training courses and workshops to students and rainwater harvesting users on subjects related to rainwater harvesting. Outreach rainwater harvesting courses are also offered in the Internets.

5. Public sectors should offer funding for rainwater harvesting research. In addition, there are a great number of non-profit private foundations specialized in community redevelopment, family health, natural disaster prevention, fire protection, etc.

6. Public sectors engaged in water supply and water resource management should be convinced that rainwater harvesting is a feasible alternative for water supply and water resources management. Users of rainwater demonstrate that they are 'good law-abiding' citizens! They use their rainwater harvesting systems to develop their own renewable and sustainable water supply without causing a burden on the public sector's finances.

7. Financial institutions should be willing to approve mortgages for rainwater harvesting development since rainwater-harvesting systems are recognized as part of a building and their construction is under a valid building permit.

8. Rainwater harvesting is also being recognized as a fire protection tool. The stored water can be used for fire fighting as well as during other emergencies.

9. Finally, from an integrated natural resources management point of view, rainwater harvesting should be included in future city planning and rural redevelopment.

8.2 Long-term Prospects (30-50 years)

- The long-term prospects are meant for thirty to fifty years from now. Because of the rapid evolution in technology, some of the prospects may seem unrealistic due to these rapid technological advances. These uncertainties may be overcome by spirit of dedicated teamwork and the private and public sectors can transform dreams into realities.

- Innovative technology in weather prediction has helped users of rainwater harvesting when to store needed rainwater for optimum benefit.
- Several international non-profit private foundations contribute funds to support RWH activities.
- Rainwater harvesting has been incorporated in new buildings that have systems designed for renewable natural resources such as energy and water. The buildings should be constructed with an integrated resources management plan. Portion of the collected rainwater can be dissociated into hydrogen and oxygen for energy production. Other portion of the collected rainwater may be used for cooling. Wastewater may also be treated for reuse. Buildings need not use water to flush toilets because new technology has produced dry toilets to dispose waste. In fact all wastes are treated and reused.

8.3 Further Development of this Technology

There is a need for water quality aspects of rainwater harvesting to be better addressed. This might come about through:

1 Development of first-flush bypass devices that are more effective and easier to maintain and operate than those currently available

2 Greater involvement of public health departments in the monitoring of water quality

3 Monitoring the quality of construction at the time of building

Other development needs include:

1 Provision of assistance from governmental sources to ensure that the appropriate-sized cisterns are built

2 Promotion of rainwater harvesting as an alternative to both government and private-sector-supplied water, with emphasis on the savings to be achieved on water bills

3 Provision of assistance to the public in sizing, locating, and selecting materials and constructing cisterns and storage tanks, and development of standardized plumbing and monitoring codes.

4 Development of new materials to lower the cost of storage

5 Preparation of guidance materials (including sizing requirements) for inclusion of rainwater harvesting in a multi-sourced water resources management environment

9. Summary and Conclusion

According to the results from the rainwater calculation it reveals that the following advantages could be achieved from this project.

- Annual cost saving is about Rs. 240,000/= to the CEB and NWSDB due to saving of energy and quantity of water.
- Increased decentralized water security and local self-reliance.
- Prevent over exploitation of ground water and preserve it at higher levels, which minimize water stress during droughts and enhancing the vitality of all life forms.
- Radically change the prevailing paradigm of dealing with rainwater.
- Minimize usage of portable water on secondary purposes.
- The engineering community can play a leading role by formulating guidelines to identify waterway reservations and advice the government to take appropriate action to enforce laws to safeguard such. This paper presents some suggestions in formulating guidelines, which may be improved further by other engineers. The engineering community as a whole and the IESL in particular can contribute positively in this regard.
- Liaise with the Universities, Technical Colleges and National Institutes of Education, Health and the relevant Government training institutions to include rainwater harvesting in their curricular training including construction and maintenance of such systems are required.
- It is necessary to amend M.C/. U.D.A by - laws on drainage in order to accommodate RWH as a strategy for localized flood mitigation infiltration facilitations and improved sanitation. Amendment should be included as requirements in the building

application and to link the "Certificate of Conformity" of future new buildings to adequate RWH facilities, along with provision of discounts in the annual rates for such.

- Rain water harvesting play on imported role in solving the ever worsening water situation for provincial building complex and productive use. It can be used to solve flood problems in this area if people encourage in use domestic rainwater collection tank.
- Catching rainwater reduces flooding due to increased paved and concrete areas preventing rainwater-penetrating undergrounds.
- Conserving of water resources and electricity, at least 50 of monthly water requirement can be met by rain water in urban areas and minimize energy input needed to operate a centralized water system. This study revealed that the expense for water could be reduced by about 50 % by using rainwater.

Acknowledgement

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