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ECOMANAGE

Integrated Ecological Coastal Zone Management System

Deliverable 2.6

SIG mapping of hydrogeologic parameters, including groundwater recharge assessment and vulnerability to pollution

(Deliverable 2.6 – 1st Part: Santos Estuary)

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SIG MAPPING OF HYDROGEOLOGIC PARAMETERS, INCLUDING GROUNDWATER RECHARGE ASSESSMENT AND VULNERABILITY TO POLLUTION (DELIVERABLE 2.6 – 1st PART: SANTOS ESTUARY)

ABSTRACT

The physical data of the Land Santos Estuary area is presented in terms of geology, soils and altimetry.

Groundwater recharge assessment methodologies are presented, namely the daily sequential soil water balance model and the surface flow hydrograph separation technique. This last technique is applied to surface flow and rainfall data of three watersheds (Cubatão, Mogi and Quilombo). The estimated recharge values are about 900 mm/yr for rainfall values of around 3300 mm/yr.

The existing geology and soil maps on the 1:500 000 scale, together with altimetry and rainfall data were used to compute the DRASTIC groundwater vulnerability index of the area. These tasks were accomplished using the Arc Info/Arc Map geographical information system. The results showed that DRASTIC index is between 117 and 176, indicating low/medium to high vulnerability, with an average value of 152. The high vulnerability class is associated to the cenozoic formations sedimentary aquifers while the low/medium vulnerability classes are associated to the basement formations.

Some considerations are presented about the information available and the obtained results.

MAPEAMENTO SIG DE PARÂMETROS HIDROGEOLÓGICOS, INCLUINDO A CARACTERIZAÇÃO DA RECARGA DAS ÁGUAS SUBTERRÂNEAS E DA VULNERABILIDADE À POLUIÇÃO (1ª PARTE: ESTUÁRIO DE SANTOS)

RESUMO

Neste relatório apresentam-se os dados físicos da área terrestre drenante para o estuário de Santos, em termos de geologia, solos e altimetria.

Apresentam-se duas metodologias para caracterização da recarga de aquíferos, nomeadamente o balanço hídrico sequencial diário a nível do solo e uma técnica de decomposição do hidrograma de escoamento superficial. Esta última técnica á aplicada com os dados de escoamento superficial e de precipitação de três bacias hidrográficas (Cubatão, Mogi e Quilombo). Os valores de recarga estimados são de cerca de 900 mm/ano para precipitações da ordem dos 3300 mm/ano.

Os mapas de geologia e de solos existentes à escala 1:500 000, em conjunto com os dados de altimetria e de precipitação, foram utilizados para calcular o índice DRASTIC de vulnerabilidade à poluição das águas subterrâneas. Estas tarefas foram realizadas utilizando o sistema de informação geográfica Arc Info/Arc Map. O índice DRASTIC obtido varia entre 117 e 176, indicando vulnerabilidade baixa/média a vulnerabilidade alta, com um índice médio de 152. A classe de vulnerabilidade alta está associada aos aquíferos sedimentares das formações cenozóicas, enquanto que as classes de vulnerabilidade baixa/média se associam às formações da base (palezóicas e pré-câmbricas).

Apresentam-se algumas considerações sobre a informação disponível e os resultados obtidos.

ACKNOWLEDGEMENTS

Pedro Chambel Leitão and Pedro Galvão from Instituto Superior Técnico for the altimetry information of Santos Estuary area and discussion and teaching about the use and the conversion of information on altimetry available on internet into Geographical Information System.

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1 General Description

1.1 Location

The study area is located in the "Unidade de Gerenciamento de Recursos Hídricos" (Water Resources Management Unit) nr 7, named "Bacia Hidrográfica da Baixada Santista" ("Baixada Santista" Hydrographic Basin). This Hydrographic Basin covers an area of 2788.82 km^2 (CETEC, 1999).

The study area is composed of the land area that flows in surface and underground to the Santos Estuary. It will be designated as the **Land Santos Estuary area**. It comprises several small watersheds listed in Table 1.

Only the western part of the Santo Amaro island (code 13 in Fig. 1) contributes to the Santos estuary. The Cabuçu watershed (code 14 in Fig. 1) flows south directly to a channel that separates the Santo Amaro island from mainland. In practical terms also the Cabuçu watershed is not flowing to the Santos estuary. So the study area is about 750 km^2.

Table 1 – Land Santos Estuary area watersheds

Watershed	Area (km^2)	Code in Fig. 1
Boturoca stream	182.84	8
Cubatão stream	175.55	9
Piaçabuçu stream	58.60	10
S. Vicente island	85.81	11
Mogi stream	68.39	12
Santo Amaro island (*)	142.70 (*)	13
Cabuçu stream (*)	69.65 (*)	14
Jurubatuba stream	79.36	15
Quilombo stream	86.88	16
Total	949.78	-

(*) Only partially flows to the estuary

Source for the watersheds, codes and areas: CETEC, 1999

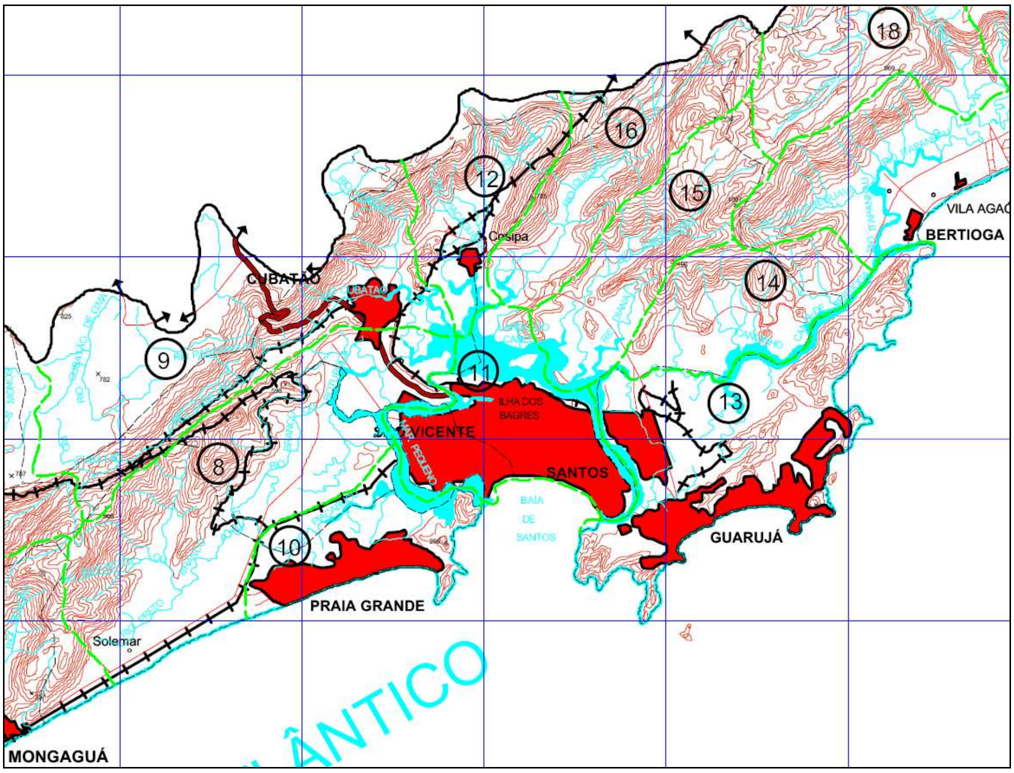


Fig. 1 – The Land Santos Estuary area rivers (blue), watersheds (green), topography (brown) and urban areas (red) [Adapted from CETEC, 1999 – Mapa Básico (M1)]

1.2 Topography

Topography may be understood by consulting Fig. 1. The area may be described by three main geomorphologic regions:

(1) the littoral plain area, around the estuary and nearby the sea in the area W of Santos, with low altitudes and where the urban areas are located,

(2) the escarpment area where the relief raises from almost the sea level to more than 700 m, and which is characterised by very sloppy hillsides, and finally,

(3) the plateau region, where the terrain surface is approximately flat, occurring in the northern part of the Cubatão and Mogi stream watersheds.

These regions may also be seen in the digital elevation model (DEM - Fig. 2) produced using the information available in the NASA web site (ftp://e0mss21u.ecs.nasa.gov/srtm/South_America/), in geographical coordinate system and transformed to the Universal Transverse Mercator (UTM) projection coordinate system using the software <ConvertToXYZ.exe> developed by the Maretec (Instituto Superior Técnico) partner. This information was imported to the ArcMap software where the digital elevation model was prepared.

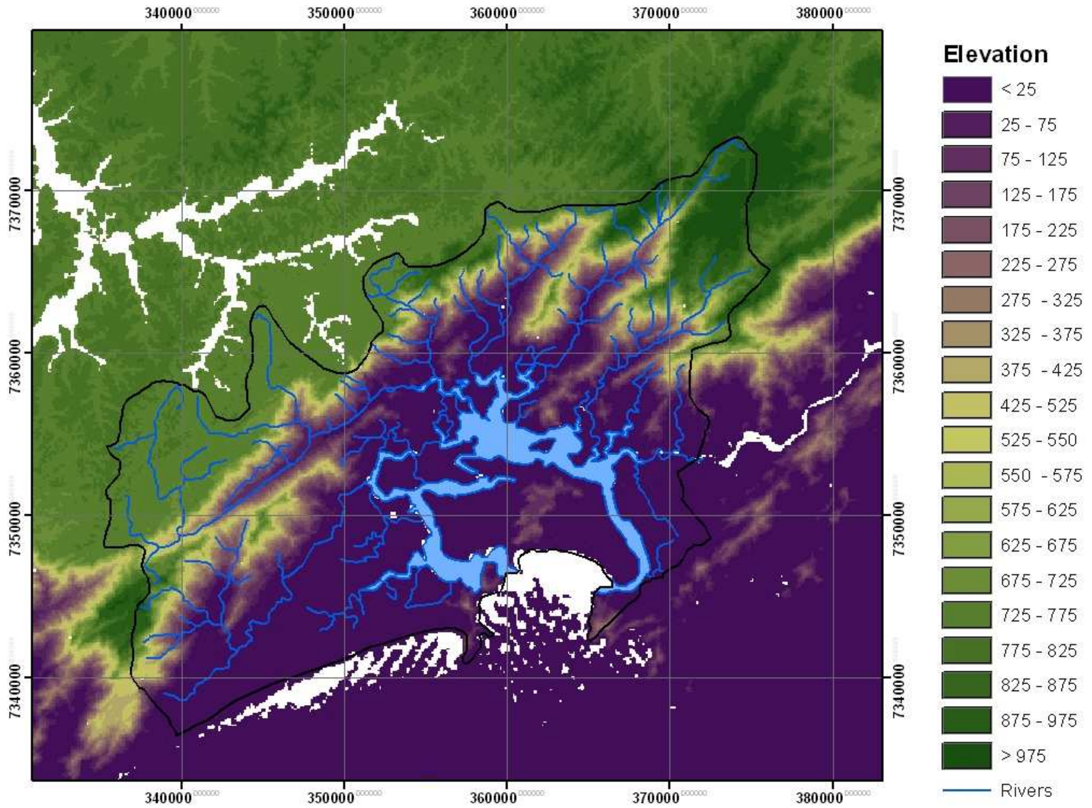


Fig. 2 – Digital elevation model (DEM) of the Land Santos Estuary area

1.3 Geology

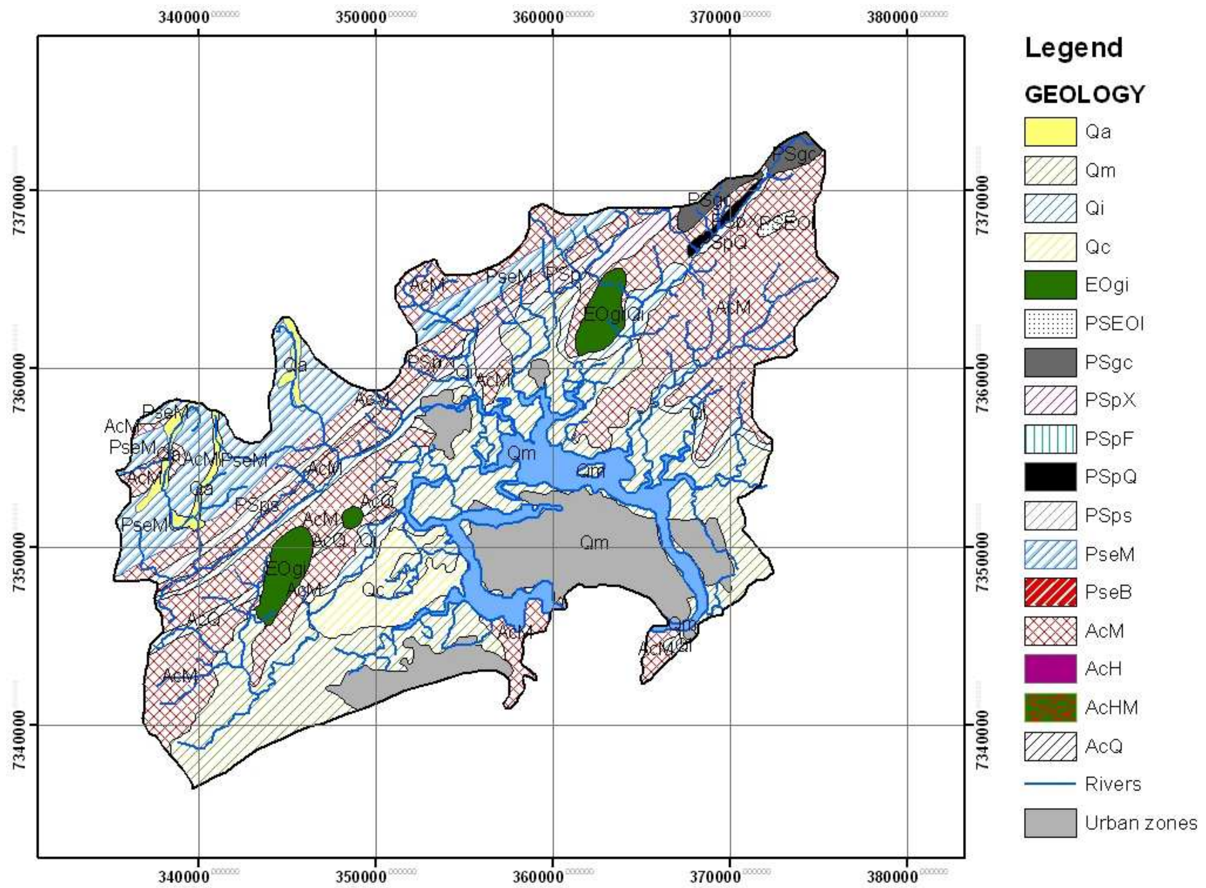
The geological description is based in CETEC (1999), that produced a geological map based on the Geological Map of São Paulo State (IPT, 1981, *in* CETEC, 1999, original scale 1:500 000). The part of the geological map published in CETEC (1999) is reproduced in Fig. 3.

The geology of the area may be grouped into (1) the basement formations and (2) cenozoic cover.

The basement formations are the result of several tectonic phases, responsible for deformation, faulting, foliation, besides metamorphism and magmatic processes, combined with variations of sea level and climate. Inland, several faulting and epeirogenesis have produced the escarpment of the actual "Serra do Mar" (Mar mountain).

In the Cenozoic, the main events may be summarized in topography modelling, tropical humid climate, sea transgression and deposition of the sedimentary sequences.

The geological description of the area is summarized in Table 2.



[Adapted from CETEC, 1999 – Mapa Geológico (M2) – Legend: consult Table 2]

Fig. 3 – Geology of the Land Santos Estuary area

Table 2 – Geology of the Land Santos Estuary area

Period (Age)	Geological formation	Lithology
Cenozoic	Qa - Alluvium	Unconsolidated sands of variable texture, associated clays and gravels
	Qm – Marine and mixed sediments	Sands, marine, sandy-siltic-clayey terms and mangroves deposits
	Qi – Undifferentiated continental sediments	Continental deposits
	Qc – Cananéia formation	Unconsolidated thin marine sands
Paleozoic	EOgi (EOγi) – Granitic to granodioritic formations	Pos-tectonic granitic bodies, thin to coarse granulation
Pre-Cambrian	PSEOI (PS∈Oγ) - Granites and granodiorites (undifferentiated)	Granites and granitoids with predominance of porphyritic term with variable granulation
	PSgc (PSγc) – Granitic formations (sin-tectonic)	Foliated granites, thin to medium granulation, porphyritic texture frequent
	PSpX – Schists (Açungui group)	Quartz-mica schists, biotire-quartz schists, muscovite-quartz schists, quartzites, marbles
	PSpF – Phyllites (Açungui group)	Phyllites, quart-phyllites and metasilts
	PSpQ – Quartzites (Açungui group)	Mica quartzites and feldspars with phyllite intercalations
	PSps – Calco-silicated rocks (Açungui group)	Calco-silicated rocks
	PseM – Migmatites (Embu complex)	Heterogeneous migmatites of variable structures
	PseB – Metabasic bodies (Embu complex)	Metabasic rocks
	AcM – Migmatites (Costeiro complex)	Migmatites with variable structures
	AcH – Granulites (Costeiro complex)	Granulites, kinzigites and charnokites
	AcHM – Charnokites (Costeiro complex)	Charnokites, kinzigites and granitic-gnaissic rocks
	AcQ – Quartzites (Costeiro complex)	Quartzites

Source: Geological Map of São Paulo State, in CETEC (1999)

Basement formations

CETEC (1999) groups the 13 basement formations into six groups according to the geological and geotechnical properties:

1 – granites, granulites and charnokites: comprising the following formations referred to in Table 2: EOγi – Granitic to granodioritic formations; PS∈Oγ - Granites and granodiorites (undifferentiated); PSγc – Granitic formations (sin-tectonic); AcH – Granulites (Costeiro complex); and AcHM – Charnokites (Costeiro complex). These rocks are in general, very hard and coherent, with oriented mineral except the intrusive granites (EOγi). It is common the occurrence of blocks of these rocks immersed in the soil or at the surface;

2 – schists and phyllites: represented by PSpX – Schists and PSpF – Phyllites. These formations predominantly present thin to mean texture, with well-developed foliation and micaceous mineralogical composition;

3 – quartzites: occurring in two different geological formations (PSpQ and AcQ), present variable granulometry and well developed foliation, determined by the orientation of the quartz minerals. They occur in very thin strips that are put in relief in the topography;

4 – calco-silicated rocks (PSpS);

5 – basic rocks (mainly metabasic) – PseB: occurring in small massifs with oriented minerals, introduced in the schists and quartzites of the Embu Complex. This group also includes intrusive basic rock bodies that occur mainly in the form of diabase dykes in the vicinity of geological faults and not mapeable at the map scale.

6 – migmatites (PseM and AcM): among the basement formations, these are the most predominant in the study area, presenting typical structures, in the form of successive bands with centimetric to metric thickness.

Sedimentary Cenozoic coverages

These coverages are formed of unconsolidated sediments, located in the plain and low areas of the Coastal Plain and in the foot of the hills. They are represented by four geological units: Qa – alluvium sediments; Qm – marine and mixed sediments; Qi – undifferentiated continental sediments; and Qc – Cananéia formation.

The Cananéia formation (Qc) is composed of old marine sandy deposits (thin sands) with sparse clayey layers, often limonited, with average thickness of 30 m.

Externally to the Cananéia formation, extensive portions of Marine and Mixed Sediments (Qm), actual and sub-actual, that include sands from beaches, marine deposits locally subject to fluvial and/or eolic action, sandy-silted-clayey terms from fluvio-marine-lacustrine deposition and mangroves deposits. The thickness of these sediments (sandy to clayey, mud with high content of biodetritical organics from mangrove) may be of more than 50 m.

The detrital deposits mainly located in the basal portion of the hills and half hillside (Undifferentiated continental sediments – Qi), are mainly composed of immature sediments, poorly sorted and often coarse material from colluvium's material. They are formed of gravels, sands and clays in variable proportions sometimes comprising numerous blocks.

The alluvium sediments (Qa) comprise unconsolidated sands of variable granulometry, as well as clay and fluvial gravels, also found in terraces.

Soil cover

The soils cover the basement rocks, having been produced from the weathering of bedrock, and whose granulometry, mineralogy and thickness vary accordingly with the basement rock lithology. As an example, soils with thinner texture, clayey and micaceous, and thicker, are found on the top of the migmatites (PSeM and ACeM), while silty-sandy soils, less thick, are found on the top of granitic formations.

1.4 Pedology

According to CETEC (1999), the Soil Map of São Paulo State, developed by the Ministery of Agriculture in 1960, at the scale 1:500 000, refers the following main groups (Fig. 4):

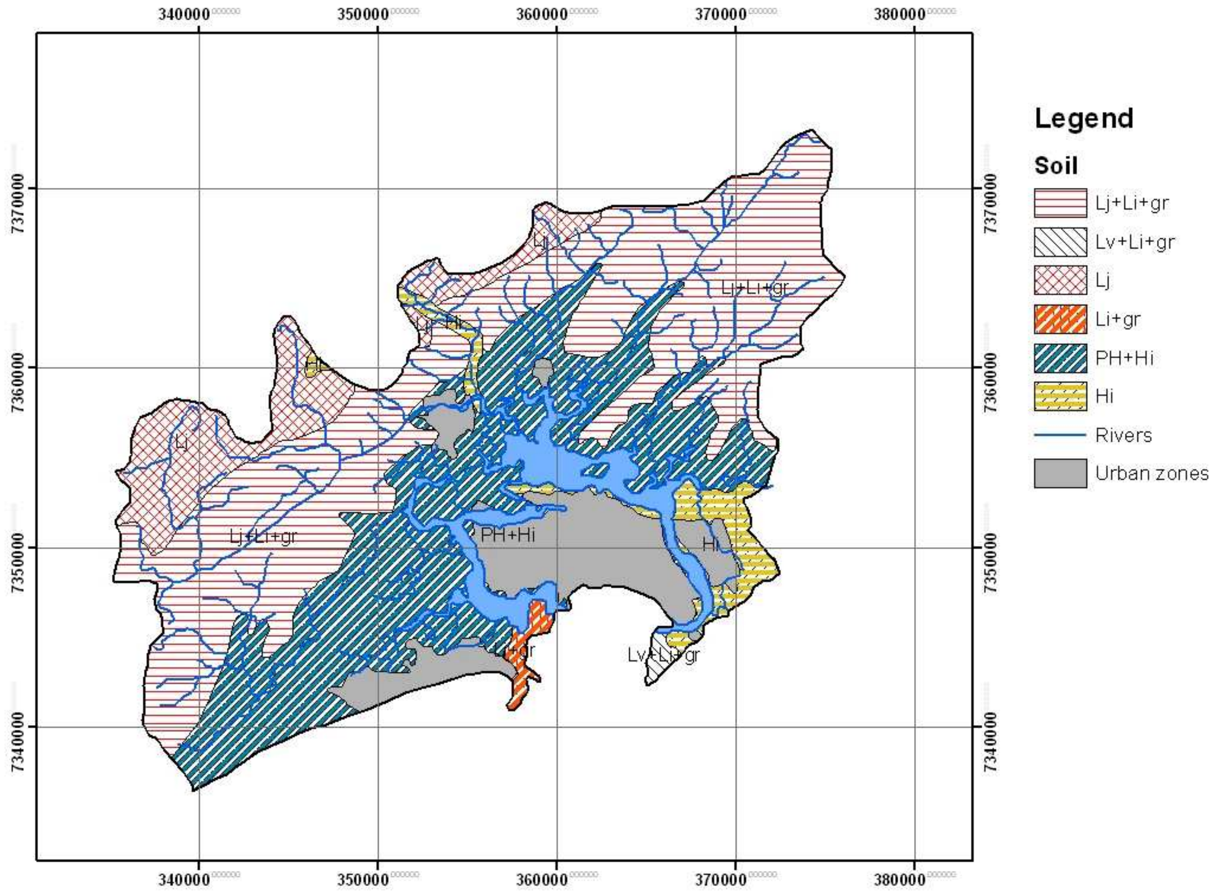
Litosoils - These soils are associated with the granitic and gnaissic geological formations, containing A and D horizons, or A, C and D horizons. The soils develop in the highest part of the mountains, with more than 60 % topographic slope.

Latosoils –

Soils poorly developed – These soils present poorly developed profile. Usually they present AC or AD horizons without B horizon.

Associations with hydromorphic soils – the principal characteristics of these soils are determined by the influence of the phreatic level. In these soils it occurs arbustive and herbaceous vegetation, besides mangroves.

Hydromorphic soils – plain soils. The influence of the phreatic level is reflected in the soil profile, identified by the accumulated organic matter in the surface horizon or by the presence of grey colors.



[Adapted from CETEC, 1999 – Mapa Pedológico I (M4) – Legend: consult Table 3]

Fig. 4 – Soil map of the Land Santos Estuary area produced by the Ministry of Agriculture / 1960 at the scale 1:500 000.

Table 3 – Soil map of the Land Santos Estuary area

Associations with Litosoil
Lj + Li + gr – "Campos do Jordão" soils and Litosoil phase granitic-gnaissic substratum
Lv + Li + gr – "Latossol Vermelho Amarelo-Orto" and Litosoil phase granitic-gnaissic substratum
Soils with Latosoil B Horizon
Lj – "Solos de Campo do Jordão"
Soils poorly developed
Li + gr – Litosoil phase granitic-gnaissic substratum
Associations with Hydromorphic Soils
PH + Hi – Hydromorphic Podzol and Hydromorphic soil
Hydromorphic Soils
Hi

Source: Soil Map of São Paulo State (Ministery of Agriculture, 1960 - scale 1:500 000 - in CETEC 1999)

2 Estimation of groundwater recharge

2.1 Introduction

The choice of a model or method to compute recharge derives from the conceptualization of the recharge process of a study area. This conceptualization is based on the physical system, its geometry, all the inputs and outputs of water and its locations. The computation of recharge is based on mass balances between water coming in, going out or being stored in the water system. These mass balances are generally water-mass balances but can also be any substance-mass balance diluted in water. Models to compute recharge may be grouped into mass balances above saturated zone and mass balances in the saturated zone. Only the water mass balances are considered.

The **water mass balances above the saturated zone** are predictive models as they quantify recharge by computing the processes prior to recharge occurrence (precipitation, infiltration, water stored in the surface and in the vadose zone). The **soil daily sequential water balance** is an appropriate method to estimate deep percolation and hence recharge. This method requires knowledge of the climatic data to characterize precipitation and reference ET, and knowledge of medium characteristic parameters, that depend on the complexity of the selected model. These models allow for estimation of distributed recharge in a region, produce results by recharge episode and may be applied to any geological medium (intergranular, fissured, karstic or more than one type). However, the more general application is for intergranular, as the soil storage is more easily quantified, and preferential pathways are less important.

The **water mass balances in the saturated zone** are response models as they represent the reaction of the groundwater medium to the recharge process. Several methods are available depending on the hydrogeological setting, for instance: (1) surface flow hydrograph separation, (2) spring discharge quantification, (3) flow quantification in aquifer sections, (4) saturated zone storage change (water level change), (5) combination of these methods, also including human water abstractions. These methods are integrative for a region and may compute recharge by episode.

In the **surface flow hydrograph separation method** base flow and direct runoff are separated. Base flow is an estimate of recharge that occurs in the area defined by a watershed when all groundwater flow inside the watershed discharges to the surface water streams inside that watershed (*i.e.* there is a coincidence between the watershed and the hydrogeological basin). The hydrogeological settings more favorable to observe this requisite are local systems of metamorphic and igneous rocks, with intergranular or fissured porosity. In some cases of sedimentary rocks with intergranular porosity, even if stratified, this requisit may still be found. The surface flow hydrograph separation method is probably the easiest recharge calculation method to use, as it does not require medium characteristic parameters, and only requires knowledge of daily precipitation and flow series.

The **spring discharge method** provides a direct measurement of the amount of water that recharged the system. It requires the knowledge of the area drained by the spring, which is not an easy value to obtain. Due to the structure of the groundwater flow paths and its significant water volumes this method is mainly applicable for karstic hydrogeological settings. For the other hydrogeological media, despite the possible occurrence of large flow springs, it is likely that it exists diffuse discharge in important amounts which difficult the quantification of discharge.

The **flow quantification in aquifer sections** is applicable to any hydrogeological medium requiring the knowledge of the recharge area upgradient the measuring section, the constant monitoring of the piezometric level in both sides of the section and the aquifer transmissivity along the measuring section. These requirements turn the application of the method more difficult.

The **water level change** is a direct consequence of recharge. Time for the application of this method is very short. For the application of this method it is required that in a study volume, the difference between groundwater flow entering and leaving the system is negligible in relation to the water level rise. This method also requires the characterization of effective porosity in the depth of water level oscillation.

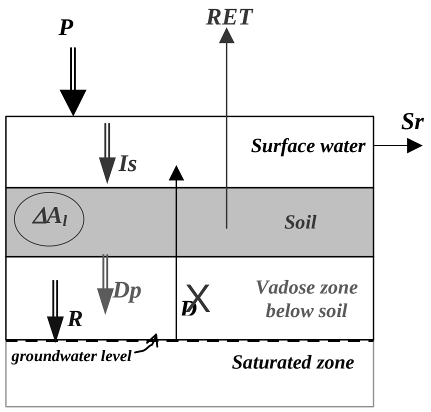
Among the referred to methods, two of them are to be applied to the Land Santos Estuary area: the **soil daily sequential water balance** and the **surface flow hydrograph separation method**. These are described in more detail in the next sections and the application of the **surface flow hydrograph separation method** is also presented to three selected watersheds in the study area.

2.2 Soil daily sequential water balance

For the conceptual case of an area where there is no artificial recharge, no surface flow entering the area, and the groundwater level is always below the soil zone, the water balance equation for the soil of that area can be expressed by (Fig. 5):

$$P - RET - \Delta A_l - Sr - Dp = \varepsilon \qquad \text{Eq. 1}$$

where ***P*** is the precipitation, ***RET*** is the effective evapotranspiration, ΔA_l is the variation (*final - initial*) of the water stored in the soil, ***Sr*** is surface runoff, ***Dp*** is deep percolation and ε is the calculation error of the balance.



P = precipitation
Sr = surface runoff
Is = surface infiltration
ΔA_l = difference of water stored in the soil in the end of the day and in the beginning of that day
RET = evapotranspiration
Dp = deep percolation
R = recharge
D = groundwater disharge

Fig. 5 – Soil water balance of an area with no discharge of groundwater and no surface flow entering in the system.

The sequential mass balance approach intends to measure or estimate and compute the ***P***, ***RET***, ***Sr*** and ΔA_l parameters, computing ***Dp*** by solving Eq. 1 considering $\varepsilon = 0$.

Recharge (***R***) is then assumed to be equal to ***Dp***:

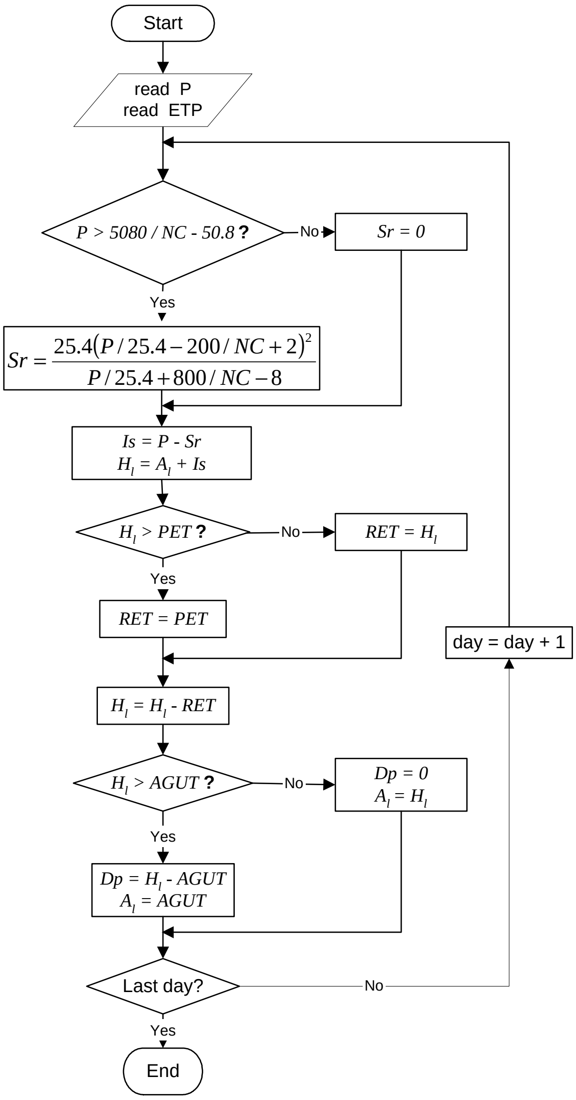
$$R = Dp = P - RET - \Delta A_l - Sr \quad \text{Eq. 2}$$

For the sequential application of that expression, it is necessary to know the values of ***P*** and of the potential evapotranspiration (***PET***) referring to each time interval, as well as of the value of maximum water reserve in the soil that can be used by plants (***AGUT***):

$$AGUT = (s_r - w_p) \cdot r_p \quad \text{Eq. 3}$$

in which s_r is the specific retention, w_p is wilting point and r_p is the depth of the plant roots. A runoff curve number (***NC***), that depends on soil permeability and on land use, is used in the process of estimating surface runoff. ***NC*** values vary between 0 (corresponds to the area with very high permeability, where all water infiltrates into the soil), and 100 (corresponds to a completely impermeable zone).

Fig. 6 shows the method programmed in the BALSEQ model (Lobo Ferreira, 1981; Lobo Ferreira & Delgado Rodrigues, 1988). The daily soil water balance method is a good method to forecast differences on total recharge in response to changing daily precipitation pattern. Moreover as a general characteristic of the method it allows for the determination of seasonal recharge. However it must be taken into account that the presented method provides a value of the water available for deep percolation, and that this deep percolation will take some time to reach the aquifer.



P = precipitation
PET = potential evapotranspiration
NC = runoff curve number
Sr = surface runoff
Is = surface infiltration
A_l = water stored in the soil in the end of the day
H_l = water stored in the soil along the day
RET = evapotranspiration
AGUT = maximum amount of water available for evapotranspiration
Dp = deep percolation

Fig. 6 – Chart flow of BALSEQ model for daily sequential water balance in the soil

2.3 Surface flow hydrograph separation method

Surface or total flow (F) of a water stream is mainly composed of (1) direct runoff or overland flow (Fd), produced in the watershed above the place where it is measured, resulting from precipitation that does not infiltrate into the soil surface and that is not retained (for example in the plants canopy, buildings, dams, etc.), and (2) base flow (Fb), resulting from water that infiltrates into the soil, goes through the subsurface and eventually comes to the surface, being the discharge of groundwater to the watershed:

$$F = Fd + Fb \qquad \textbf{Eq. 4}$$

The hydrograph represents surface flow against time (Fig. 7). The two large flow components of total flow (Fd and Fb) may be separated in the hydrograph. Several methods exist (*c.f. e.g.* Linsley et al., 1975). One of these, which is the basis of the methodology used in this study, consists in connecting total flow that exists in the beginning of the rising limb to the total flow that exists in the end of direct runoff. Linsley et al. (1975) present the following equation to estimate time from the hydrograph peak until a point located in the end of the recession curve that reflects the end of direct runoff (A is watershed area above the measuring station in km² and *n* is number of days):

$$n = 0{,}8 \cdot A^{0{,}2} \quad \textbf{Eq. 5}$$

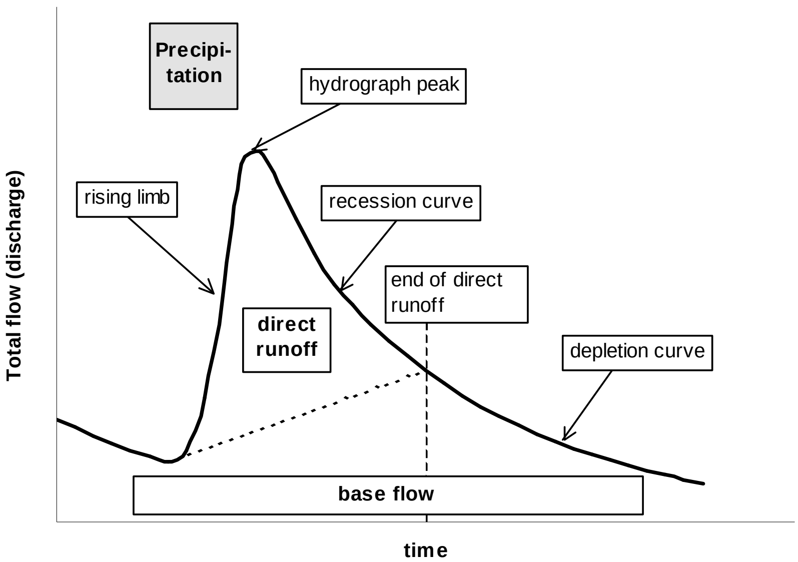


Fig. 7 – Method to separate total flow in direct runoff and base flow

The procedures developed for hydrograph separation (HS) use a daily time step and were programmed in DECHIDR_VB using Visual Basic 6.0. The general technique for the separation follows the method represented in Fig. 8, though in this case the total flow in the beginning of the rising limb is always zero. The method consists in plotting a straight line linking the hydrograph origin of the precipitation/recharge (P/R) episode under analysis with total flow calculated in the beginning of day n + 1. Day n [computed with Eq. 5] refers to the number of days with direct runoff after the hydrograph peak [Fig. 8A] or the end of the precipitation if this exceeds the hydrograph peak [Fig. 8B]. The area above the line represents direct runoff of the episode under analysis while the area below the line represents its base flow.

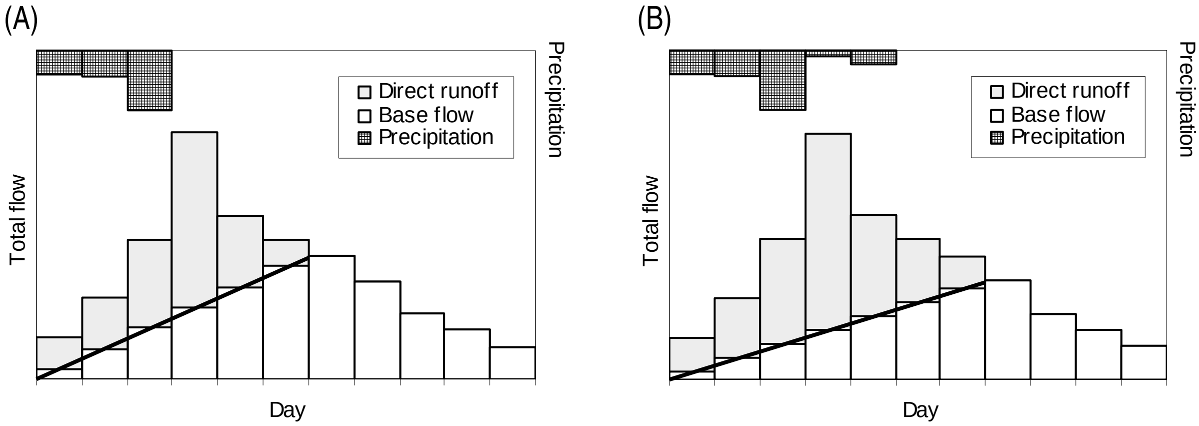


Fig. 8 – Example of the process of hydrograph separation, for n = 2 day, using as criterion (A) the day of the hydrograph peak, (B) the last precipitation day

The HS turns to be a more complex process due to the occurrence of different superimposed episodes, which cause that, in the same day, the recession of several P/R episodes may be occurring. To deal with this situation a set of procedures is developed in order to isolate distinct P/R episodes. The separation is carried out sequentially considering the input data series: date, total flow and precipitation.

The first step consists in determining the first day of a new P/R episode (episode B). Considering total flow existing since the beginning of the episode under analysis (episode A), it is considered that a new episode (episode B) starts when: (1) total flow is larger or equal to total flow in the previous day and total flow in the previous day is lower than total flow calculated two days before; (2) total flow is larger than total flow in the day before and this is equal to total flow calculated two days before. Depending on the selected option, the beginning of that episode is considered valid (1) in the day in which the previous conditions were met, independently of the occurrence of precipitation, (2) only in the first day of the rising limb after the day in which the previous conditions were met and the precipitation is larger than a precipitation threshold, defined as the minimum daily precipitation that must occur before direct runoff is generated.

Being established the first day of the episode B, the second step consists in determining the recession of episode A. To do this, a recession coefficient (α) of episode A is found by fitting a negative exponential curve of the type:

$$F = F_0 \,.\, \mathrm{EXP}(-\alpha \,.\, t) \qquad \textbf{Eq. 6}$$

to the flows of the recession or depletion periods in the days before the beginning of episode B, being F total flow in the end of time t of the decreasing period and F_0 total flow when t = 0. The selection of the days used to compute a follows the criteria presented in Oliveira (2001). With the computed α, the water mass balance between the amount of precipitation that contributes to the episode and the corresponding total flow may be controlled. In this case, to accept α it is required that total flow is not larger than precipitation. If it is larger, a new α is searched that meets the equality between total flow and precipitation (see Oliveira, 2001).

The third step consists in calculating flow of episode A in the days that follow the starting of episode B, using Eq. 6, with F_0 given by total flow in the day before the starting of episode B.

The advantages of the HS method in estimating recharge are: (1) it is easy to apply with precipitation and flow data usually available; (2) only requires the definition of two parameters (1- number of days in which there is direct runoff, and 2- precipitation threshold – if this parameter is considered); (3) it is not constrained to fixed parameters of the watershed because each P/R episode is considered separately; (4) it is able to control and maintain the mass balance between precipitation and the produced total flow; (5) it integrates all the processes of the hydrological cycle that take place in the watershed, measuring the response of the system to those processes; (6) it is applicable to the whole watershed, not requiring the definition of recharge and discharge areas of the groundwater medium.

The following limitations are referred to: (1) it is vulnerable to errors in the determination of total flow; (2) it is dependent on the as good as possible estimation of precipitation in the watershed, mainly if the balance between precipitation and total flow is used; (3) it considers that water streams are only receiving bodies (does not consider bank storage) and that all groundwater discharges to those streams inside the watershed; (4) it may not be used directly if there are dams that inhibit natural flow.

Base flow (or the discharge of groundwater) of a watershed is a measure of the groundwater recharge that has occurred in the watershed if: (1) there was no lateral groundwater flow entering the watershed, (2) groundwater flowed towards the surface streams inside the watershed, (3) there was no evaporation from shallow groundwater, (4) there was no human groundwater abstraction or its value was small enough and could be neglected.

2.4 Application of the surface flow hydrograph separation method to the Santos case study area watersheds

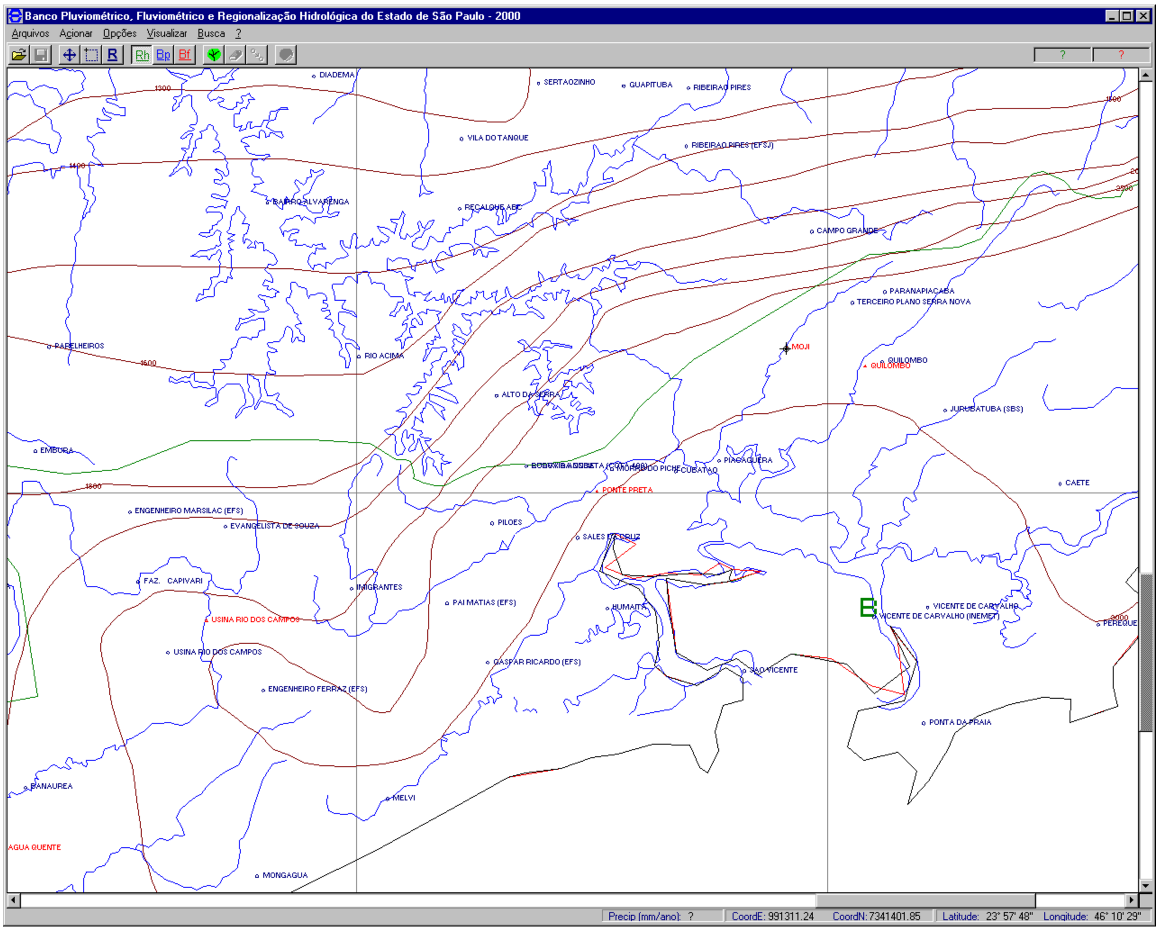
2.4.1 Available information

Three watersheds in the Land Santos estuary area are partially monitored. The surface flow gauge stations locations are given in Table 4 and ploted in Fig. 9. The area is also covered by a number of rain gauge stations whose locations are given in Table 5 and in Fig. 9. This figure also plots average annual precipitation lines, that ranges from 1800 mm/yr (in the NW part) to more than 3000 mm/yr in the major part of the area.

Table 4 – Location of the surface flow gauge stations and record periods

Reference	Watershed	Time record	Latitude	Longitude	Area (km2)
3E093-Moji	Mogi	8/1972-10/1974	23° 49' 21"	46° 21' 40"	19.00
3E095-Quilombo	Quilombo stream	10/1971-11/1987	23° 49' 49"	46° 19' 12"	57.00
3E077-Ponte_Preta	Cubatão	11/1966-6/1969	23° 53' 39"	46° 27' 26"	131.00

(Source: BcDaee2000, 2000)



(Source: BcDaee2000, 2000)

Fig. 9 – Location of rain and surface flow gauge stations in the Land Santos estuary area.

Table 5 – Location of the rain gauge stations and record periods

Reference	Time record	Latitude	Longitude	Altitude
E3-235-JurubatubaSBS	1/12/1971-28/02/1975	23° 51'	46° 15'	200.00
E3-252-Quilombo	12/3/1978-4/4/1988	23° 48'	46° 17'	60.00
E3-037-Paranapiacaba	1/1/1936-30/6/1998	23° 46'	46° 17'	820.00
E3-104-TerceiroPlanoSerraNova	1/11/1960-31/3/1982	23° 48'	46° 18'	670.00
E3-041-Caete	6/2/1937-31/7/2000	23° 53'	46° 13'	200.00
E3-045-ViventeDeCarvalho	1/4/1942-31/5/2000	23° 55'	46° 17'	3.00
E3-070-PontaDaPraia	1/6/1937-31/7/2000	24° 00'	46° 17'	3.00
E3-039-VicenteDeCarvalho_INEMET	1/1/1936-29/2/1960	23° 57'	46° 17'	2.00
E3-038-Piacaguera	1/1/1936-30/6/2000	23° 51'	46° 22'	5.00
E3-144-Morro do Piche	1/11/1949-25/5/1989	23° 53'	46° 27'	105.00
E3-143_RodoviaAnchieta_Cota400	1/1/1950-30/4/1994	23° 53'	46° 28'	400.00
E3-101_Cubatao	20/7/1944-31/12/1999	23° 53'	46° 25'	6.00
E3-064_SalesDaCruz	1/8/1939-17/6/1988	23° 55'	46° 28'	250.00
E3-228_Humaita	30/8/1939-31/7/2000	23° 57'	46° 27'	10.00
E3-236_Piloes	1/3/1972-31/3/1992	23° 53'	46° 29'	100.00
E3-241-Imigrantes	1/6/1972-30/9/1986	23° 55'	46° 35'	760.00
F3-010-Melvi	1/9/1982-31/7/2000	24° 01'	46° 32'	10.00

(Source: BcDaee2000, 2000)

2.4.2 Mogi watershed

Mogi watershed was monitored by the 3E093-Moji stream flow gauge station from 8/1972 till 10/1974. The station covers 19 Km^2 of the watershed which represents 28 % of the watershed area.

The nearest rain gauge station with daily precipitation data for the same period is E3-037 - Paranapiacaba. A file with daily values of date, surface flow and precipitation was prepared, and this was used as the input file of program DECHIDR_VB.

There are two gaps in the records of the stream flow: (1) from 3-8-1972 to 10-8-1972 and (2) from 25-2-1973 to 29-3-1973. These gaps were filled with the value of zero.

The computed values of total flow, direct runoff and base flow of the Mogi watershed are represented in Table 6.

Table 6 – Monthly values of total flow, direct runoff and base flow of the Mogi watershed

DATE	F: TOTAL FLOW (mm)	PRECIPITATION (mm)	Fd: DIRECT RUNOFF (mm)	Fb: BASE FLOW (mm)	Fd / F (%)	Fb / F (%)
08-1972 (1)	75	194	36	39	48%	52%
09-1972	209	270	144	65	69%	31%
10-1972	519	516	432	87	83%	17%
11-1972	915	321	677	238	74%	26%
12-1972	213	196	155	59	73%	28%
01-1973	370	491	309	61	84%	16%
02-1973 (2)	322	365	238	84	74%	26%
03-1973 (2)	10	256	10	0	100%	0%
04-1973	379	439	296	83	78%	22%
05-1973	282	481	178	104	63%	37%
06-1973	152	100	90	62	59%	41%
07-1973	172	280	124	47	72%	27%
08-1973	151	151	75	75	50%	50%
09-1973	444	363	423	21	95%	5%
10-1973	411	291	327	84	80%	20%
11-1973	502	497	327	174	65%	35%
12-1973	418	302	308	110	74%	26%
01-1974	638	543	434	205	68%	32%
02-1974	221	168	197	24	89%	11%
03-1974	460	361	351	109	76%	24%
04-1974	204	232	160	44	78%	22%
05-1974	170	44	115	55	68%	32%
06-1974	185	220	130	55	70%	30%
07-1974	178	116	157	21	88%	12%
08-1974	115	59	53	63	46%	55%
09-1974	260	287	186	74	72%	28%
10-1974	326	276	228	98	70%	30%
Average	307	290	228	79	74%	26%

(1) From 3-8-1972 to 10-8-1972 there is a gap in stream flow records
(2) From 25-2-1973 to 29-3-1973 there is a gap in stream flow records

Table 6 shows that in average, base flow represents 26 % of surface flow. However, the application of the methodology presented in section 2.3, that controls the water mass balance between the amount of precipitation that contributes to the episode and the corresponding total flow, produced plenty situations in which the assigned α is 100 (see Annex 1) because precipitation is lower than total runoff for those episodes. In these situations, when the total flow separation is carried out there are a number of episodes where total flow is given by direct runoff (with null base flow). All these situations may be due to the insufficient characterisation of the precipitation in the watershed, as there is only one rain gauge station. If the watershed precipitation is larger than the used one, then the situations with watershed precipitation lower than stream flow would lower and the results provided by the applied methodology would be different. So the estimations of base flow are thought to be a lower estimation of the base flow that really existed in the watershed. Table 6 is a good indication that the precipitation is computed by deficiency in relation to the stream flow, as the average precipitation for the analysed period is lower than total flow.

With the obtained values it was possible to construct the probability distribution function diagram that is shown in Fig. 10. The median base flow is 1.73 mm/d and the average base flow is 2.60 mm/d.

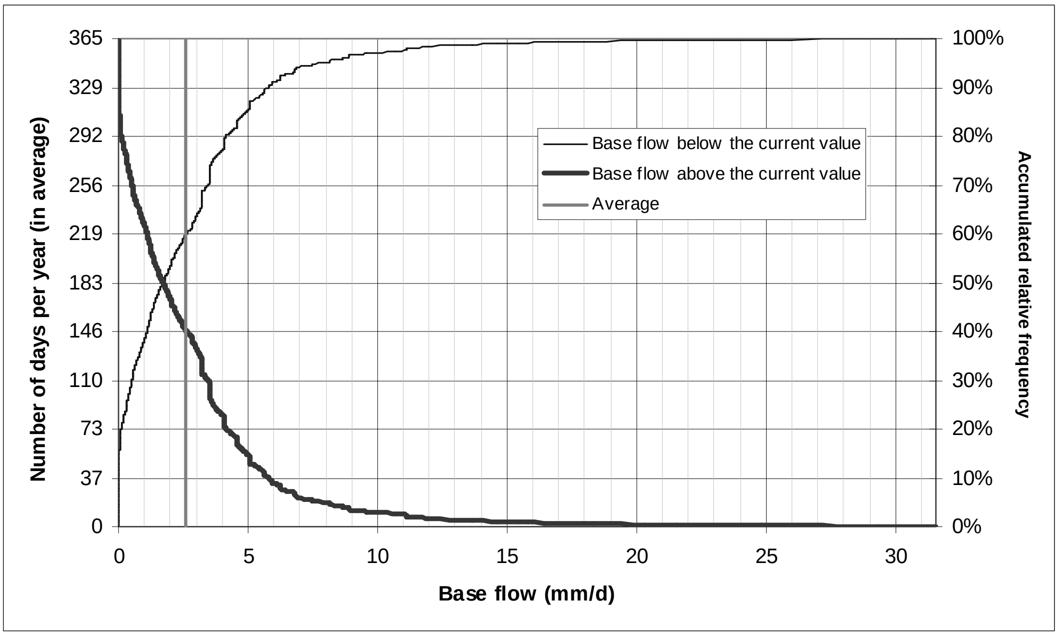


Fig. 10 - Probability distribution function of base flow in Mogi watershed

Assuming that the conditions referred to in the end of section 2.3 are met, this base flow is an estimation (lower limit) of the recharge that occurred in the system.

2.4.3 Quilombo watershed

Quilombo watershed was monitored by the 3E095-Quilombo stream flow gauge station from 10/1971 till 11/1987. The station covers 57 Km^2 of the watershed which represents 66 % of the watershed area. There are some gaps in the stream flow records: (1) 1-10-1971 to 20-10-1971; (2) 12-4-1973 to 28-5-1973; (3) 4-10-1974 to 31-12-1974; (4) 24-2-1975 to 16-4-1975; (5) 24-8-1975 to 30-9-1975; (6) 3-6-1987 to 13-8-1987; (7) 19-11-1987 to 30-11-1987.

The nearest rain gauge station with daily precipitation data for the same period is E3-037-Paranapiacaba. The consistence of this precipitation series was verified only for the period 01-01-1972 to 31-12-1976. The precipitation value in 06-09-1987 is missing and it was assigned a value of zero.

A file with daily values of date, surface flow and precipitation was prepared, and this was used as the input file of program DECHIDR_VB. To run the program the missing data in the stream flow records were filled with the value of zero.

The computed values of total flow, direct runoff and base flow of the Quilombo watershed are represented in Table 7.

Table 7 – Monthly values of total flow, direct runoff and base flow of the Quilombo watershed

DATE	F: TOTAL FLOW (mm)	PRECIPITATION (mm)	Fd: DIRECT RUNOFF (mm)	Fb: BASE FLOW (mm)	Fd / F (%)	Fb / F (%)
10-1971(1)	28	221	0	28	0%	100%
11-1971	90	145	36	54	40%	60%
12-1971	149	446	74	76	49%	51%
01-1972	164	372	80	84	49%	51%
02-1972	299	426	198	101	66%	34%
03-1972	174	199	38	136	22%	78%
04-1972	185	228	91	94	49%	51%
05-1972	110	86	40	70	36%	64%
06-1972	98	12	47	50	48%	52%
07-1972	47	88	13	35	27%	73%
08-1972	77	194	43	34	56%	44%
09-1972	81	270	54	28	66%	34%
10-1972	202	516	94	108	47%	53%
11-1972	166	321	61	105	37%	63%
12-1972	107	196	36	71	34%	66%
01-1973	281	491	196	85	70%	30%
02-1973	161	365	56	104	35%	65%
03-1973	132	256	68	64	52%	48%
04-1973(2)	47	439	20	27	42%	58%
05-1973(2)	13	481	0	13	0%	100%
06-1973	104	100	13	91	12%	88%
07-1973	115	280	48	67	42%	58%
08-1973	88	151	18	70	21%	79%
09-1973	144	363	73	71	51%	49%
10-1973	145	291	45	100	31%	69%
11-1973	166	497	67	98	41%	59%
12-1973	161	302	59	102	37%	63%
01-1974	324	543	198	126	61%	39%
02-1974	131	168	45	86	34%	66%
03-1974	201	361	116	85	58%	42%
04-1974	126	232	55	71	44%	56%
05-1974	92	44	46	46	50%	50%
06-1974	101	220	45	56	45%	55%
07-1974	63	116	29	35	45%	55%
08-1974	44	59	4	40	9%	91%
09-1974	75	287	43	32	57%	43%
10-1974(3)	12	276	11	1	91%	9%
11-1974(3)	0	210	0	0	-	-
12-1974(3)	0	356	0	0	-	-
01-1975	271	487	185	86	68%	32%
02-1975(4)	213	475	105	108	49%	51%
03-1975(4)	0	302	0	0	-	-
04-1975(4)	62	144	0	62	0%	100%
05-1975	105	107	15	90	14%	86%
06-1975	65	89	13	52	20%	80%
07-1975	98	179	58	41	59%	41%
08-1975(5)	29	121	4	26	13%	87%
09-1975(5)	0	216	0	0	-	-
10-1975	96	251	44	52	46%	54%
11-1975	164	467	88	76	54%	46%
12-1975	395	781	253	142	64%	36%
01-1976	886	884	756	131	85%	15%
02-1976	181	389	95	86	53%	47%
03-1976	262	305	70	192	27%	73%
04-1976	570	630	422	148	74%	26%
05-1976	155	261	39	116	25%	75%

DATE	F: TOTAL FLOW (mm)	PRECIPITATION (mm)	Fd: DIRECT RUNOFF (mm)	Fb: BASE FLOW (mm)	Fd / F (%)	Fb / F (%)
06-1976	111	130	15	96	14%	86%
07-1976	154	252	61	93	40%	60%
08-1976	121	360	46	75	38%	62%
09-1976	101	283	34	67	34%	66%
10-1976	101	281	27	74	26%	74%
11-1976	92	238	28	64	30%	70%
12-1976	200	388	111	89	55%	45%
01-1977	218	408	104	114	48%	52%
02-1977	103	81	15	89	14%	86%
03-1977	92	225	31	61	34%	66%
04-1977	265	552	174	91	66%	34%
05-1977	124	162	47	77	38%	62%
06-1977	82	122	41	41	50%	50%
07-1977	49	44	11	38	22%	78%
08-1977	45	157	14	31	31%	69%
09-1977	72	307	33	38	47%	53%
10-1977	143	373	66	77	46%	54%
11-1977	111	277	42	69	38%	62%
12-1977	150	365	45	105	30%	70%
01-1978	409	615	267	142	65%	35%
02-1978	103	267	15	88	15%	85%
03-1978	326	529	190	135	59%	41%
04-1978	106	187	19	87	18%	82%
05-1978	99	223	40	59	41%	59%
06-1978	64	94	16	49	24%	76%
07-1978	38	82	11	27	30%	70%
08-1978	47	189	20	27	42%	58%
09-1978	43	85	9	34	21%	79%
10-1978	29	146	13	16	44%	56%
11-1978	90	504	50	40	55%	45%
12-1978	84	339	16	68	19%	81%
01-1979	133	331	58	75	44%	56%
02-1979	76	155	15	62	19%	81%
03-1979	217	507	129	88	59%	41%
04-1979	131	239	37	94	28%	72%
05-1979	100	186	23	77	23%	77%
06-1979	72	162	14	58	19%	81%
07-1979	106	234	46	61	43%	57%
08-1979	74	231	29	45	39%	61%
09-1979	195	502	83	112	43%	57%
10-1979	176	253	113	64	64%	36%
11-1979	262	660	160	102	61%	39%
12-1979	264	391	140	124	53%	47%
01-1980	212	383	74	138	35%	65%
02-1980	355	629	182	173	51%	49%
03-1980	156	296	54	102	35%	65%
04-1980	123	245	34	89	28%	72%
05-1980	64	40	4	59	7%	93%
06-1980	50	180	13	36	27%	73%
07-1980	79	238	37	41	47%	53%
08-1980	68	255	26	42	38%	62%
09-1980	92	206	42	50	46%	54%
10-1980	145	406	61	84	42%	58%
11-1980	105	289	27	78	26%	74%
12-1980	170	364	79	91	46%	54%
01-1981	207	321	59	148	29%	71%
02-1981	125	189	21	104	17%	83%
03-1981	139	352	56	83	40%	60%

DATE	F: TOTAL FLOW (mm)	PRECIPITATION (mm)	Fd: DIRECT RUNOFF (mm)	Fb: BASE FLOW (mm)	Fd / F (%)	Fb / F (%)
04-1981	254	307	137	116	54%	46%
05-1981	122	184	36	86	30%	70%
06-1981	63	51	11	52	18%	82%
07-1981	63	206	26	37	41%	59%
08-1981	53	186	13	40	25%	75%
09-1981	54	192	23	31	43%	57%
10-1981	102	277	40	62	39%	61%
11-1981	142	258	71	70	50%	50%
12-1981	221	441	118	103	54%	46%
01-1982	197	435	96	102	49%	51%
02-1982	143	336	56	86	40%	60%
03-1982	176	207	80	97	45%	55%
04-1982	128	252	32	96	25%	75%
05-1982	74	111	15	59	20%	80%
06-1982	81	212	46	35	57%	43%
07-1982	55	164	17	38	31%	69%
08-1982	91	234	39	52	43%	57%
09-1982	129	395	69	60	54%	46%
10-1982	101	305	38	63	38%	62%
11-1982	125	254	56	70	44%	56%
12-1982	174	402	69	105	40%	60%
01-1983	136	222	36	100	27%	73%
02-1983	386	534	264	122	68%	32%
03-1983	207	443	90	116	44%	56%
04-1983	197	346	65	132	33%	67%
05-1983	167	281	56	110	34%	66%
06-1983	216	283	114	102	53%	47%
07-1983	93	118	38	55	41%	59%
08-1983	86	165	30	56	35%	65%
09-1983	155	431	88	67	56%	44%
10-1983	183	489	78	105	43%	57%
11-1983	94	113	12	83	12%	88%
12-1983	71	197	25	47	35%	65%
01-1984	120	451	83	37	69%	31%
02-1984	129	196	59	70	46%	54%
03-1984	102	330	55	47	54%	46%
04-1984	90	244	32	58	36%	64%
05-1984	60	82	9	51	16%	84%
06-1984	34	23	8	26	23%	77%
07-1984	41	237	26	15	64%	36%
08-1984	112	358	51	61	46%	54%
09-1984	70	177	21	49	30%	70%
10-1984	94	296	50	43	54%	46%
11-1984	82	270	36	46	44%	56%
12-1984	150	393	71	79	47%	53%
01-1985	316	887	203	112	64%	36%
02-1985	185	384	81	104	44%	56%
03-1985	172	296	120	52	70%	30%
04-1985	204	493	76	128	37%	63%
05-1985	113	280	24	90	21%	79%
06-1985	83	165	34	49	41%	59%
07-1985	45	50	19	25	43%	57%
08-1985	35	176	16	19	46%	54%
09-1985	69	311	44	25	63%	37%
10-1985	22	119	6	16	28%	72%
11-1985	44	168	26	18	59%	41%
12-1985	34	220	17	17	51%	49%
01-1986	27	136	8	19	30%	70%

DATE	F: TOTAL FLOW (mm)	PRECIPITATION (mm)	Fd: DIRECT RUNOFF (mm)	Fb: BASE FLOW (mm)	Fd / F (%)	Fb / F (%)
02-1986	156	473	117	40	75%	25%
03-1986	203	521	105	98	52%	48%
04-1986	140	418	73	67	52%	48%
05-1986	99	143	18	81	18%	82%
06-1986	76	92	27	50	35%	65%
07-1986	159	374	99	60	62%	38%
08-1986	78	159	30	48	39%	61%
09-1986	72	312	36	36	51%	49%
10-1986	84	158	37	48	43%	57%
11-1986	162	456	89	73	55%	45%
12-1986	198	507	123	75	62%	38%
01-1987	281	457	210	71	75%	25%
02-1987	211	330	95	116	45%	55%
03-1987	233	202	118	115	51%	49%
04-1987	137	311	61	76	45%	55%
05-1987	160	395	80	80	50%	50%
06-1987(6)	7	320	3	5	36%	64%
07-1987(6)	0	128	0	0	-	-
08-1987(6)	32	141	8	24	26%	74%
09-1987	85	361	36	49	42%	58%
10-1987	117	374	47	70	40%	60%
11-1987(7)	48	127	8	40	17%	83%
Average	132	287	62	70	47%	53%

(1) From 1-10-1971 to 20-10-1971 there is a gap in stream flow records
(2) From 12-4-1973 to 28-5-1973 there is a gap in stream flow records
(3) From 4-10-1974 to 31-12-1974 there is a gap in stream flow records
(4) From 24-2-1975 to 16-4-1975 there is a gap in stream flow records
(5) From 24-8-1975 to 30-9-1975 there is a gap in stream flow records
(6) From 3-6-1987 to 13-8-1987 there is a gap in stream flow records
(7) From 19-11-1987 to 30-11-1987 there is a gap in stream flow records

Table 7 shows that the average total flow is 132 mm/month from which 70 mm/month correspond to base flow. The monthly average values are computed by deficit because they used the zero values that were assigned to surface flow to fill the gaps of its series. By using the same values the average base flow represents 53 % of average surface flow.

The results of the application of the hydrograph separation methodology are presented by precipitation/surface runoff episode in Annex 2.

With the obtained values and discarding the zero values assigned to fill the gaps it was possible to construct the probability distribution function diagram that is shown in Fig. 11. The median base flow is 2.22 mm/d and the average base flow is 2.42 mm/d.

Assuming that the conditions referred to in the end of section 2.3 are met, this base flow is an estimation of the recharge that occurred in the Quilombo watershed area.

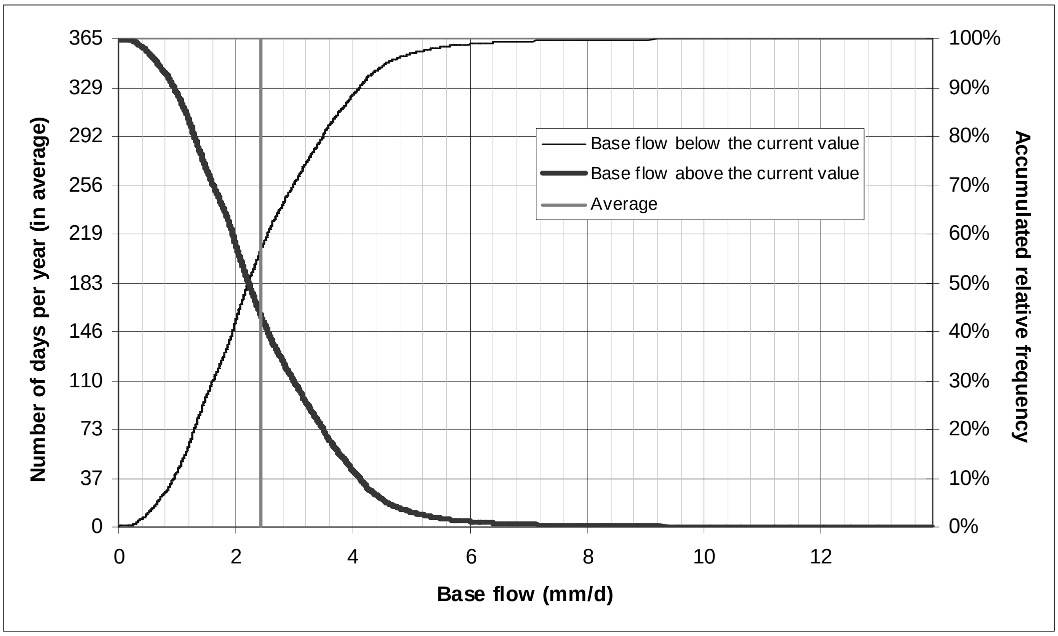


Fig. 11 - Probability distribution function of base flow in Quilombo watershed

2.4.4 Cubatão watershed

Cubatão watershed was monitored by the 3E077-Ponte Preta stream flow gauge station from 11/1966 till 6/1969. The station covers 131 Km^2 of the watershed which represents 75 % of the watershed area.

There are some gaps in the stream flow records: (1) 1-11-1966 and 2-11-1966; (2) 1-5-1968 to 31-5-1968; (3) 10-10-1968; (4) 9-4-1969; (5) 14-5-1969 to 22-5-1969; (6) 16-6-1969 and 17-6-1969.

The daily precipitation data was taken from rain gauge station "E3-064 - Sales da Cruz". There are two gaps in the precipitation series: the whole months of March/1967 and January/1968. The consistence of the precipitation series was not verified.

A file with daily values of date, surface flow and precipitation was prepared, and this was used as the input file of program DECHIDR_VB. To run the program the missing stream flow data were filled with the value of zero while the precipitation records were filled with the values recorded in the "E3-144 – Morro do Piche" rain gauge station (consistence not verified).

The computed values of total flow, direct runoff and base flow of the Cubatão watershed are represented in Table 8.

Table 8 – Monthly values of total flow, direct runoff and base flow of the Cubatão watershed

DATE	F: TOTAL FLOW (mm)	PRECIPITATION (mm)	Fd: DIRECT RUNOFF (mm)	Fb: BASE FLOW (mm)	Fd / F (%)	Fb / F (%)
11-1966(1)	336	465	166	170	50%	50%
12-1966	766	631	692	74	90%	10%
01-1967	284	796	137	147	48%	52%
02-1967	554	799	400	154	72%	28%
03-1967	628	495	575	53	92%	8%
04-1967	195	222	100	94	51%	49%
05-1967	91	64	24	68	26%	74%
06-1967	129	169	63	66	49%	51%
07-1967	111	137	57	54	52%	48%
08-1967	76	72	34	42	45%	55%
09-1967	131	187	71	60	54%	46%
10-1967	220	197	183	37	83%	17%
11-1967	371	253	319	52	86%	14%
12-1967	240	263	114	126	47%	53%
01-1968	205	195	124	80	61%	39%
02-1968	110	31	42	68	38%	62%
03-1968	246	544	179	67	73%	27%
04-1968	228	678	138	90	60%	40%
05-1968(2)	0	233	0	0	--	--
06-1968	62	67	4	57	7%	93%
07-1968	57	148	27	31	46%	54%
08-1968	95	89	55	41	57%	43%
09-1968	100	127	48	52	48%	52%
10-1968(3)	102	207	46	57	45%	55%
11-1968	93	23	16	77	18%	82%
12-1968	115	602	45	71	39%	61%
01-1969	103	166	36	68	35%	65%
02-1969	210	180	151	59	72%	28%
03-1969	209	193	131	78	63%	37%
04-1969(4)	185	368	100	85	54%	46%
05-1969(5)	59	1	24	35	41%	59%
06-1969(6)	62	188	28	34	45%	55%
Average	199	275	129	70	65%	35%

(1) In 1-11-1966 and 2-11-1966 there are no stream flow records
(2) From 1-5-1968 to 31-5-1968 there is a gap in the stream flow records
(3) In 10-10-1968 there is no stream flow record
(4) In 9-4-1969 there is no stream flow record
(5) From 14-5-1969 to 22-5-1969 there is a gap in the stream flow records
(6) In 16-6-1969 and 17-6-1969 there are no stream flow records

Table 8 shows that the average total flow is 199 mm/month from which 70 mm/month correspond to base flow. The monthly average values are computed by deficit because they used the zero values that were assigned to surface flow to fill the gaps of its series. By using the same values the average base flow represents 35 % of average surface flow.

The results of the application of the hydrograph separation methodology are presented by precipitation/surface runoff episode in Annex 3.

With the obtained values and discarding the zero values assigned to fill the gaps it was possible to construct the probability distribution function diagram that is shown in Fig. 12. The median base flow is 1.98 mm/d and the average base flow is 2.42 mm/d.

Assuming that the conditions referred to in the end of section 2.3 are met, this base flow is an estimation of the recharge that occurred in the Cubatão watershed area.

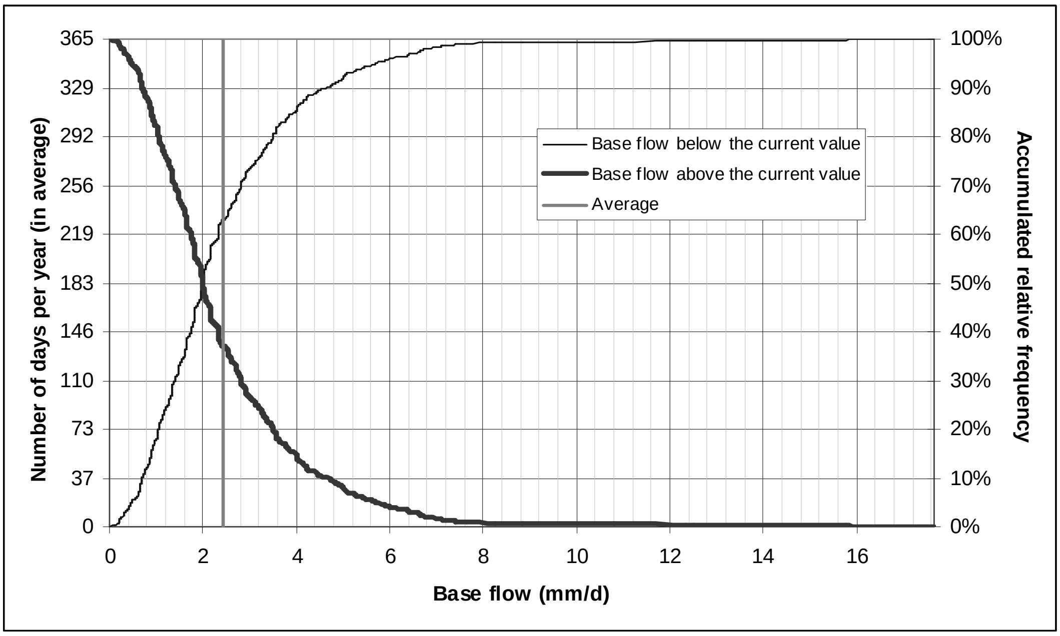


Fig. 12 - Probability distribution function of base flow in Cubatão watershed

2.4.5 Analysis of the results

It should be noted that the hydrograph separation technique performs better in the case of lower precipitation values with precipitation episodes clearly separated. In the Santos case study area, precipitation is very high and in about 2/3 of the year there is precipitation. Besides, the characterisation of the precipitation in each watershed is not as good as desirable because for each watershed only one rain gauge station was used. So far the available data did not allow making a better characterisation of the precipitation in each watershed.

For the presented reasons, precaution should be taken with the obtained results.

3 Groundwater vulnerability to pollution

3.1 Concept of vulnerability to pollution

The text presented in this and in the next section, was derived from Lobo Ferreira and Cabral (1991). It is believed that the most useful definition of vulnerability is one that refers to the intrinsic characteristics of the aquifer, which are relatively static and mostly beyond human control. It is proposed therefore that the groundwater vulnerability to pollution be defined, in agreement with the conclusions and recommendations of the international conference on "Vulnerability of Soil and Groundwater to Pollutants", held in 1987 in The Netherlands, as (Duijvenbooden *et al.*,1987):

"**the sensitivity of groundwater quality to an imposed contaminant load, which is determined by the intrinsic characteristics of the aquifer**".

Thus defined, vulnerability is distinct from pollution risk. Pollution risk depends not only on vulnerability but also on the existence of significant pollutant loading entering the subsurface environment. It is possible to have high aquifer vulnerability but no risk of pollution, if there is no significant pollutant loading; and to have high pollution risk in spite of low vulnerability, if the pollutant loading is exceptional. It is important to make clear the distinction between vulnerability and risk. This because risk of pollution is determined not only by the intrinsic characteristics of the aquifer, which are relatively static and hardly changeable, but also on the existence of potentially polluting activities, which are dynamic factors which can in principle be changed and controlled.

Considerations on whether a groundwater pollution episode will result in serious threat to groundwater quality and thus to its (already developed, or designated) water supply are not included in the proposed definition of vulnerability. The seriousness of the impact on water use will depend not only on aquifer vulnerability to pollution but also on the magnitude of the pollution episode, and the value of the groundwater resource.

3.2 Methods for vulnerability assessment

Given the definition of vulnerability proposed as above, it is important to recognise that the vulnerability of an aquifer will be different for different pollutants. For example, groundwater quality may be highly vulnerable to the loading of nitrates at the surface, originated in agricultural practices, and yet be little vulnerable to the loading of pathogens.

In view of this reality, it is scientifically most sound to evaluate vulnerability to pollution in relation to a particular class of pollutant, such as nutrients, organics, heavy metals, pathogens, etc., *i.e.* to create specific vulnerability maps. This point of view has been expressed by other authors (*e.g.* Foster, 1987), and some work has been done in specific vulnerability mapping. An example is the work of Canter *et al.*, 1987 for nitrate pollution of agricultural origin. Alternatively, vulnerability mapping could be performed in relation to groups of polluting activities (Foster, 1987), such as unsewered sanitation, agriculture, and particular groups of industries. This has been attempted for some activities. An example is the work of Le Grand (1983) for waste disposal.

Although it is recognised that this specific vulnerability mapping is scientifically sounder, one must realise that there will generally be insufficient available data to perform specific vulnerability mapping. Therefore, it is necessary to adopt a mapping system that is simple enough to apply using the data generally available, and yet is capable of making best use of those data in a technically valid and useful way. Various such systems of vulnerability evaluation and ranking have been developed and applied in the past. Examples are Albinet and Margat (1970), Haertl (1983), Aller *et al.* (1987), and Foster (1987).

Some of the systems for vulnerability evaluation and ranking include a vulnerability index which is computed from hydrogeological, morphological and other aquifer characteristics in some well-defined way. The adoption of an index has the advantage of, in principle, eliminating or minimising subjectivity in the ranking process. Given the multitude of authors and potential users of vulnerability maps in EU countries, Lobo-Ferreira and Cabral (1991) proposed for Portugal and the EU the definition of vulnerability in agreement with the conclusions and recommendations of the international conference on "Vulnerability of Soil and Groundwater to Pollutants", mentioned above, *i.e.* "*the sensitivity of groundwater quality to an imposed contaminant load, which is determined by the intrinsic characteristics of the aquifer*" and further suggested that a vulnerability index should be used for the vulnerability mapping to be developed for European Community Countries.

Such a standardised index has been adopted in the U.S., Canada and South Africa, and is currently used in those countries: the index DRASTIC, developed by Aller *et al.* (1987) for the U.S. EPA. This index has the characteristics of simplicity and usefulness.

3.3 The DRASTIC method

3.3.1 General description

The index of vulnerability DRASTIC (Aller *et al.*, 1987) was created for the following conditions:

1) the contaminant is introduced at the ground surface;

2) the contaminant is flushed into the ground water by precipitation;

3) the contaminant has the mobility of water; and

4) the area evaluated with DRASTIC is 100 acres (0.4 km^2) or larger.

The index of vulnerability DRASTIC corresponds to the weighted average of 7 values corresponding to 7 hydrogeologic parameters:

1 - Depth to the water (D)

2 - Net Recharge (R)

3 - Aquifer material (A)

4 - Soil type (S)

5 - Topography (T)

6 - Impact of the unsaturated zone (I)

7 - Hydraulic Conductivity (C)

The DRASTIC index is a concept that joins several features that characterise the subsurface medium and its specificity (Fig. 13).

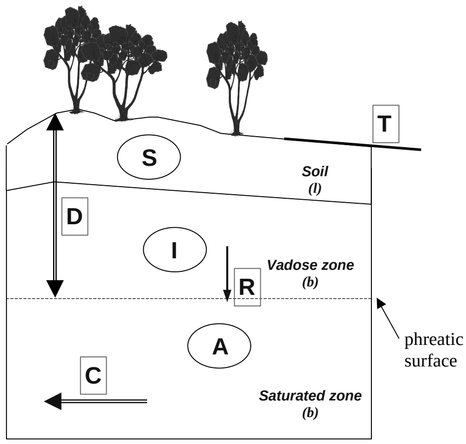


Fig. 13 - Parameters of the DRASTIC method

A value between 1 and 10 to each parameter, except R for which the value ranges between 1 and 9, is attributed, depending on local conditions. High values correspond to high vulnerability. The attributed values are generally obtained from tables, which give the correspondence between local hydrogeologic characteristics and the parameter value. Next, the local index of vulnerability is computed through multiplication of the value attributed to each parameter by its relative weight, and adding up all seven products:

$$DRASTIC = D_R D_W + R_R R_W + A_R A_W + S_R S_W + T_R T_W + I_R I_W + C_R C_W$$

where R = rating and W = weight.

Thus, each parameter has a predetermined, fixed, relative weight that reflects its relative importance to vulnerability. The most significant factors have weights of 5 and the least significant a weight of 1. A second weight has been assigned to reflect the agricultural usage of pesticides. In Table 9 the factors are presented together with the weights respectively for standard DRASTIC applications and for DRASTIC pesticide applications.

The minimum value of the standard DRASTIC index is therefore 23 and the maximum value is 226. Such extreme values are very rare, the most common values being within the range 50 to 200. Whereas the corresponding minimum and maximum values for pesticide DRASTIC index are 26 and 256 respectively.

Table 9 - Assigned weights for DRASTIC features used in Standard and Pesticide DRASTIC

Feature	Standard Weight	Pesticide Weight
Depth to Water (D)	5	5
Net Recharge (R)	4	4
Aquifer Media (A)	3	3
Soil Media (S)	2	5
Topography (T)	1	3
Impact of the Vadose Zone Media (I)	5	4
Hydraulic Conductivity of the Aquifer (C)	3	2

(Aller *et al.*, 1987)

Table 10 to Table 16 show the ratings to be assigned to each parameter depending on the value that it assumes or the class to where it belongs. In some cases a rating interval and a typical rating is shown, which represents, in the case of the rating interval, the values that the parameter can assume, depending for instance on the clay content, the weathering conditions, or the fissuring in the case of the aquifer media.

3.3.2 Depth to the water (D)

The depth to water table is an important factor in the evaluation of groundwater pollution vulnerability primarily because it determines the thickness of material through which a contaminant must travel before reaching the aquifer. The depth to water table is also important because it provides an opportunity for oxidation and it may help to determine the contact time of pollutant with the surrounding media. In general, there is a greater chance for attenuation of pollutants to occur as the depth to the water table increases because deeper water levels imply longer travel times in the vadose zone with an exception that if the vadose media is fractured or karstified then the travel time is independent of the depth of water level. Because the DRASTIC was originally designed for evaluation of unconfined aquifers, special definitions must have to be assumed when evaluating depth to water for a confined aquifer. When an aquifer is confined, depth to water should be the depth to the top of the aquifer or base of the confining layer and therefore the measurements of depths to water levels in the piezometers do not provide the depth to water in confined aquifers. This parameter has to be derived from the geological cross sections and borehole data. In case of leaky confined aquifers the user has to treat such aquifers either as unconfined or fully confined based on the qualitative assessment of leakage quantity through the confining layer. Similarly in aquifers of large areas with varying degree of confinement the user has to make appropriate decisions to assign spatially varying aquifer nature and hence spatially varying depths to water levels.

Table 10 shows the ratings to assign for the D parameter as a function of the depth to the water table in the case of an unconfined aquifer or the depth to the top of a confined aquifer.

Table 10 - Ranges and ratings for D - Depth to water

Range (feet)	Range (m)	Rating
0 - 5	0 - 1.5	10
5 - 15	1.5 - 4.6	9
15 - 30	4.6 - 9.1	7
30 - 50	9.1 - 15.2	5
50 - 75	15.2 - 22.9	3
75 - 100	22.9 - 30.5	2
> 100	> 30.5	1

(Aller *et al.*, 1987)

3.3.3 Net Recharge (R)

The quantity of net recharge represents the amount of water per unit area of land, which penetrates the ground surface and reaches the water table. The term net recharge is defined as the total quantity of water which is applied to the ground surface and infiltrates to reach the aquifer. This includes average annual infiltration amount and does not consider distribution, intensity or duration of recharge event like precipitation. This recharged water is thus available to disperse, dilute and transport a contaminant vertically into the vadose zone to the water table and horizontally within the aquifer. The greater the recharge, the greater the potential for groundwater pollution. However, at certain quantity of recharge the pollution event may in turn decrease due to dilution of the contaminant.

Table 11 shows the ratings to assign for the R parameter as a function of recharge values.

Table 11 - Ranges and ratings for R - net Recharge

Range (inches)	Range (mm)	Rating
0 - 2	0 - 51	1
2 - 4	51 -102	3
4 - 7	102 - 178	6
7 - 10	178 - 254	8
> 10	> 254	9

(Aller *et al.*, 1987)

3.3.4 Aquifer media (A)

Aquifer media refers to a lithological unit that serves as an aquifer. Aquifer media plays an important role in dissipation and transportation of the pollutants once introduced into them. The parameters like effective porosity, grain size, clay contents and aquifer thickness are the four main characteristics that control dissemination and transportation of the contaminants in the saturated zone, the aquifer. The effective porosity determines the travel time of the contaminant, higher the porosity faster the movement of the contaminant in the aquifer. The smaller grain size of the aquifer material provides for larger effective surface area for the contaminants to adsorb, exchange and disseminate in the aquifer. The clay is well known for its ion exchange capacity and if an aquifer has some clay content in it, then the contaminants would generally react with it and exchange some of the ions thereby reducing the contaminant concentrations. Therefore when looking into the aquifer media for assigning a DRASTIC rating one should look into the overall aspects of aquifer material in terms of its texture, composition, physical properties (especially effective porosity) and also clay content.

Table 12 shows the ratings to assign to parameter A depending on the aquifer material. A rating and a typical rating are shown. The rating is represented by an interval, which represents the values that the parameter can assume, depending for instance on the clay content, the weathering conditions, or fissuring. The typical rating is an average value and should be used if no more detailed information about the aquifer material is available.

Table 12 - Ranges and ratings for A - Aquifer media

Range	Rating	Typical Rating
Massive Shale	1 - 3	2
Metamorphic/Igneous	2 - 5	3
Weathered Metamorphic/Igneous	3 - 5	4
Glacial Till	4 - 6	5
Bedded Sandstone, Limestone and Shale Sequence	5 - 9	6
Massive Sandstone	4 - 9	6
Massive Limestone	4 - 9	6
Sand and Gravel	4 - 9	8
Basalt	2 - 10	9
Karst Limestone	9 - 10	10

(Aller *et al.*, 1987)

3.3.5 Soil media (S)

Soil media refers to that uppermost portion of the vadose zone which is characterised by significant biological activity. In the DRASTIC classification, the soil media is referred to be the upper weathered zone of the earth which averages to a depth of two metres or less from ground surface. Eleven different soil types which were given ratings of between 1 and 10 were defined by Aller *at al* (1987) – Table 13.

Table 13 - Ranges and ratings for S - Soil media

Range	Rating
Thin or Absent	10
Gravel	10
Sand	9
Peat	8
Shrinking and/or Aggregated Clay (montmorillonite or smectite clays)	7
Sandy Loam	6
Loam	5
Silty Loam	4
Clay Loam	3
Muck	2
Nonshrinking and Nonaggregated Clay (Kaolinitic or illitic clays)	1

(Aller *et al.*, 1987)

3.3.6 Topography (T)

The term topography refers to the slope and slope variability of the land surface. Topography has an influence on the soil development and therefore has an effect on contaminant attenuation. The topography also determines the contact time of contaminants with the soil and in case of unconfined aquifers the topography can provide information about the groundwater gradients and velocities. Smaller ground slopes are always potential for groundwater pollution compared to steep slopes. It has been found that the grounds with 0 to 2 percent slopes provide the greatest opportunity for the contaminants to infiltrate because of low surface runoff and large contact time between the contaminant and the ground.

In DRASTIC method percent slope is considered for rating topography, which is equal to the vertical "rise" divided by the horizontal "run" (gradient of ground level). The classes and ratings to apply are given in Table 14.

Table 14 - Ranges and ratings for T – Topography

Range (Percent Slope)	Rating
0 - 2	10
2 - 6	9
6 - 12	5
12 - 18	3
> 18	1

(Aller *et al.*, 1987)

3.3.7 Impact of the vadose zone media (I)

By definition, the vadose zone includes all the unsaturated media below the ground and above the water table, including the soil zone. As the soil was already considered in the S parameter, the I parameter of the DRASTIC method will refer only to the unsaturated media below the bottom of the soil layer and above the water table in case of unconfined aquifer. Where an aquifer is confined, the extent of vadose zone includes all media below the bottom of the soil layer and above the top of the confined aquifer. In many situations, the vadose zone will not be a true vadose zone, because part of the saturated media may have to be treated as the vadose zone. When evaluating a confined aquifer, the "confining layer" must be treated as a vadose zone and be always assigned a rating of 1. The type of vadose zone media determines the attenuation characteristics of the material below the soil horizon and above the water table. Biodegradation, neutralisation, mechanical filtration, chemical reactions, volatilisation and dispersion are the processes that may occur within the vadose zone. The amount of biodegradation and volatilisation however, decreases with depth. The media also controls the path length and routing, thus affecting the time available for attenuation and the quantity of material found. The routing is strongly influenced by any fracturing present in the vadose media.

As for the A parameter, for each material it was considered a rating interval and a typical rating. The ratings and typical ratings are presented in Table 15.

Table 15 - Ranges and ratings for I - Impact of the vadose zone media

Range	Rating	Typical Rating
Confining Layer	1	1
Silt/Clay	2 - 6	3
Shale	2 - 5	3
Limestone	2 - 7	6
Sandstone	4 - 8	6
Bedded Limestone, Sandstone, Shale	4 - 8	6
Sand and Gravel with significant Silt and Clay	4 - 8	6
Metamorphic/Igneous	2 - 8	4
Sand and Gravel	6 - 9	8
Basalt	2 - 10	9
Karst Limestone	8 - 10	10

(Aller *et al.*, 1987)

3.3.8 Hydraulic Conductivity of the aquifer (C)

The rate of contaminant movement in the saturated zone is also controlled by the rate of groundwater movement. The parameter aquifer hydraulic conductivity is used to measure the rate of water flow in the aquifer. By definition the aquifer hydraulic conductivity is the ability of the aquifer to transmit water. The higher the conductivity the higher the rate of contaminant movement. The hydraulic conductivity is the result of the interconnected pores (effective porosity) in the sediments and fractures in the consolidated rocks.

Table 16 shows the ratings to assign for the C parameter as a function of the hydraulic conductivity.

Table 16 - Ranges and ratings for C - Hydraulic conductivity

Range (gpd/ft2)	Range (m/d)	Rating
1 - 100	0 - 4.1	1
100 - 300	4.1 - 12.2	2
300 - 700	12.2 - 28.5	4
700 - 1000	28.5 - 40.7	6
1000 - 2000	40.7 - 81.5	8
> 2000	> 81.5	10

(Aller *et al.*, 1987)

3.4 Application of the DRASTIC method

3.4.1 Depth to the water (D)

The characterisation of the depth to the water table should be made based on information of the position of the top of the aquifer. This information may be derived from well logs or from the measurement of the phreatic level in wells located in the unconfined aquifers. As can be understood from the previous sections of this report this data is not available (i.e. there is no section concerning hydrogeology). So, some assumptions were made based on the available information on soils, topography (ground surface slope) and geology. Naturally these assumptions should be confirmed with field information on the required parameter.

D parameter was set to 10 (top of the aquifer less than 1.5 m from ground surface) in the coastal plain areas where the hydromorphic soils are maped (soil Hi on Fig. 4), and in the alluvium formations (Qa in the geological map - Fig. 3) along and nearby the rivers where groundwater depth should be small. Also in all the areas where the topography is very irregular (sloppy hillsides) in areas with fractured formations, mainly metamorphic and igneous, and with very high rainfall values that most of the times provoke the erosion of the surface weathered material. In these circumstances it is assumed that groundwater flow takes place very near the surface. These formations probably do not correspond to true aquifers but the existing groundwater is supposed to exist very close to the surface. The soil associations "Lj+Li+gr" and "Li+gr" are very much related to these conditions, the reason why the soil map (Fig. 4) was used to define these areas.

For the formations associated to the Qm formation – marine and mixed sediments (Fig. 3), which occur in low altitudes, it is assumed that the water level is between 1.5 m and 4.6 m, which correspond to D = 9.

Finally for the formations that occur in the plateau area, and those corresponding to the Continental deposits (Qi - Fig. 3) that occur in the foot of the hilly areas, a rating of 7 (4.6 m to 9.1 m) is assigned. This rating intends to minimize the possible error of not knowing the real value while at the same time seems to be a reasonable value for these type of formations.

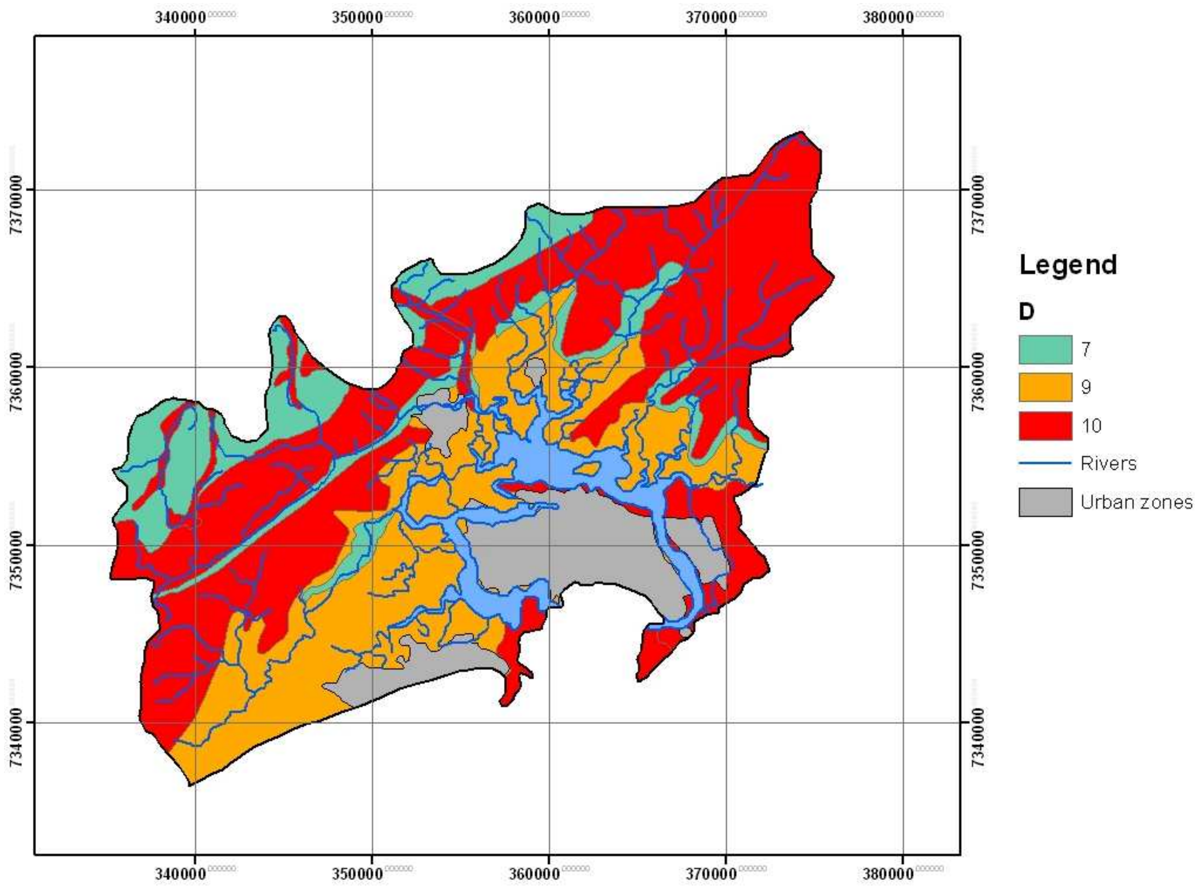


Fig. 14 – Characterisation of the Depth to the water (D)

3.4.2 Net Recharge (R)

The assignment of this rating is based on the knowledge of the climatological conditions of the area. With such high rainfall values (around 3000 mm/yr) it is thought that at least 254 mm/yr will be recharge. This value corresponds immediately to the maximum rating of the R parameter. The high recharge rates were also calculated using the surface flow hydrograph separation results (section 2.4) where values as high as 70 mm/month (840 mm/yr) were obtained in the studied watersheds. Only in the areas where the water level is at or close to the ground surface, recharge may be lower because water is not allowed to infiltrate. Nevertheless it is assumed in these areas that a 254 mm/yr vertical infiltration of rainfall takes place. So, all the area is assigned a rating R = 9.

3.4.3 Aquifer media (A)

The characterisation of the aquifer media is based directly on the geological map (Fig. 3). There were no other sources of information as well logs or geological cross sections. The rating assignment was made using Table 12. All metamorphic and igneous formations were assigned a rating A = 4. The cenozoic formations (with the important presence of sandy formations) were assigned a rating of A = 8. The map with the characterisation of this parameter is shown in Fig. 15.

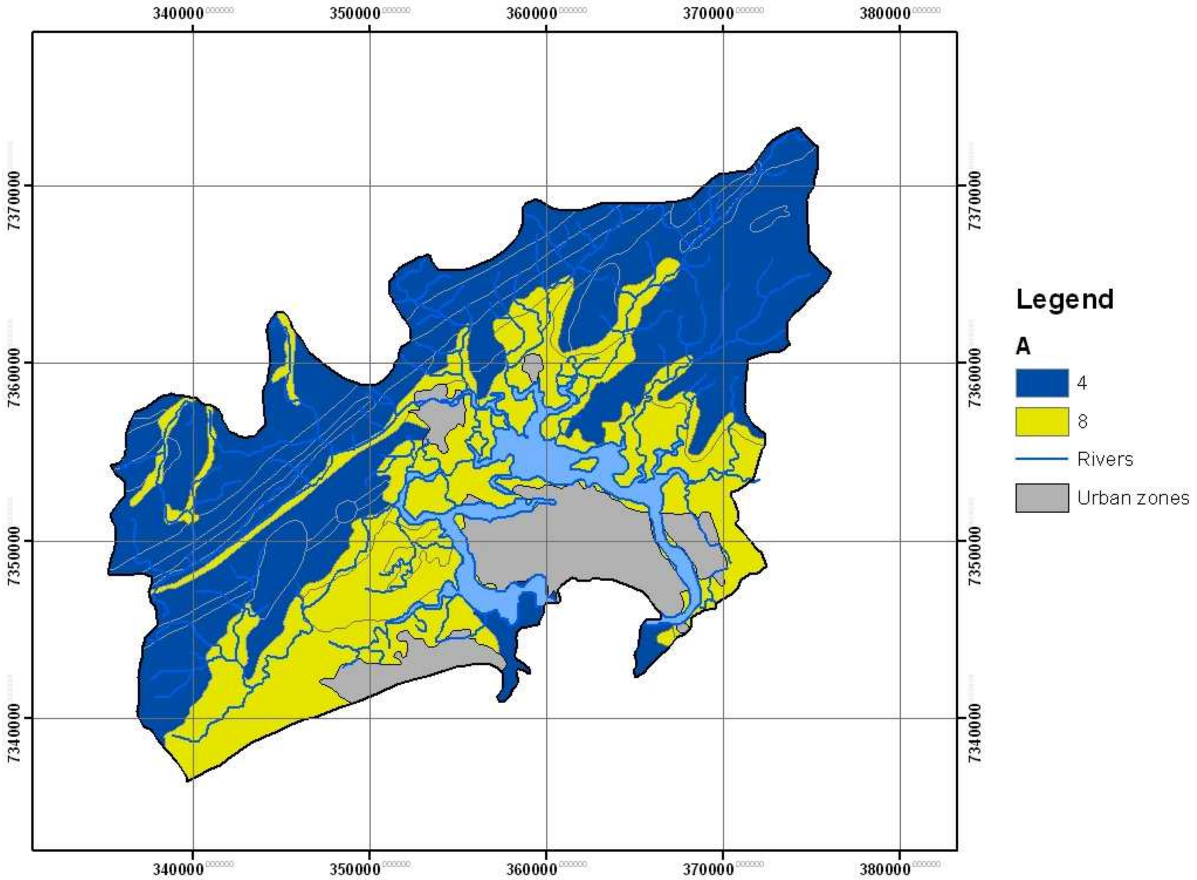


Fig. 15 – Characterisation of the Aquifer media (A)

3.4.4 Soil media (S)

The characterisation of the soil media was based on the available information of the soils (section 1.4). This information is not in the adequate scale for a good characterisation of this parameter and it was not found an explanatory text on the mapped soils in the area.

It was used a PhD work (Rossi, 1999) for the Guaratuba watershed, located 30 to 40 km east of the Land Santos Estuary area, where climatic, geological and morphological conditions are about the same. It is assumed that with these same conditions also the vegetation cover and the soils would be similar. The Guaratuba watershed is also located in the Water Resources Management Unit nr 7 having also been studied in CETEC (1999).

The soil map (Fig. 4) and the geological map (Fig. 3) that exist for Santos area also exist for Guaratuba watershed (in CETEC, 1999). With this information an attempt was made to relate the soil information from Rossi (1999), that also presents soil maps and altitude maps, with the soil and geological maps from CETEC (1999). Table 17 shows the relations between morphology geology and soils from both sources in land Santos estuary area and in Guaratuba watershed.

Being established this relation the soil profile description from Rossi (1999) was used to assign the S parameter in the studied area.

The soils considered in the studied area are those presented in Table 3.

The soil associations PH + Hi (Hydromorphic podzol and hydromorphic soil) and Hi (Hydromorphic soil), mainly associated with the plain areas, were characterised with the soil profiles presented by Rossi (1999) for the P + PH (Podzol + Hydromorphic podzol) association. In all presented profiles, these soils developed from the marine sediments and present more than 90 % of sand in the granulometric analysis. According to Table 13 the rating for sand soil class is S = 9.

For the Hi (hydromorphic soils), as the minimum soil thickness that is considered in assigning the S parameter is 25 cm, if the water table is at the surface, the soil thickness may not be enough to consider the soil properties. In this case a soil value of S = 10 should be assigned.

Table 17 – Relation between morpholofy, geology and soils in Guaratuba and Land Santos Estuary area using two different sources of information

<table>
<tr><td rowspan="2">Morphology</td><td rowspan="2">Layer</td><td>Land Santos Estuary</td><td colspan="2">Guaratuba</td></tr>
<tr><td colspan="2">(CETEC, 1999)</td><td>(Rossi, 1999)</td></tr>
<tr><td rowspan="2">Plain</td><td>Geology</td><td colspan="2">Qm – marine sediments</td><td>Qm – marine sediments</td></tr>
<tr><td>Soil</td><td>PH + Hi - Hydromorphic podzol and hydromorphic soil
Hi - Hydromorphic soil</td><td>PH + Hi - Hydromorphic podzol and hydromorphic soil</td><td>P + PH – Podzol + Hydromorphic podzol</td></tr>
<tr><td rowspan="2">Escarpment</td><td>Geology</td><td>PSγc – corpos graníticos</td><td>AcM – migmatitos
PSeM - migmatitos</td><td>PEgr - granitos</td></tr>
<tr><td>Soil</td><td colspan="2">LJ+Li+gr – “Campos do Jordão” soils and Litosoil phase granitic gnaissic substratum</td><td>C+PV – Cambisoil + red-yellow Podzol</td></tr>
<tr><td rowspan="2">Plateau</td><td>Geology</td><td>AcM – Migmatites
PSeM - Migmatites</td><td>AcM - Migmatites</td><td>Acg - Gneiss</td></tr>
<tr><td>Soil</td><td>LJ – “Campos do Jordão” soils</td><td>LJ+Li+gr – “Campos do Jordão” soils and Litosoil phase granitic gnaissic substratum</td><td>C+LV – Cambisoil + red-yellow Latosoil</td></tr>
</table>

The soil association LJ+Li+gr (“Campos do Jordão” soils and Litosoil phase granitic gnaissic substratum), mainly related to the escarpment areas, correspond to the C+PV (Cambisoil + red-yellow Podzol) soil association from Rossi (1999). These soils are associated with the granitic areas. As referred to for the Podzol soils, S = 9. For the Cambisoil the granulometric analysis presented in Rossi (1999) show one soil profile that present as the most protective horizon (in terms of pollutant spreading) sandy clay (S = 3), four soil profiles that present as the most protective horizon sandy loam (S = 6), and one soil profile with sandy clay loam as the most protective layer (S = 5). Not being possible to differentiate cambisoil (S = 3, 5 or 6) from podzol (S = 9), and inside cambisoils between different most protective layers, a general value of S = 7 is assigned for the LJ+Li+gr soil association.

An exception is considered where slopes are larger than 18 % (slope obtained using a 100 m cell side grid) where it is assumed that due to rain conditions and topography the soils are very thin, and hence, a value of S = 10 is assigned.

The soil association Li + gr (Litosoil phase granitic-gnaissic substratum) as a definition is assigned a rating of S = 10, as these are very thin soils on top of the bedrock.

The soils LJ ("Campos do Jordão" soils) develop in the plateau over migmatitic rocks (AcM & PSeM – both migmatites). The same rocks occur in the Guaratuba watershed where the soil association according to Rossi (1999) is C+LV (Cambisoil + red-yellow Latosoil). Instead of migmatites, Rossi (1999) refers the occurrence of gnaissic rocks. These types of rocks may be similar. The soil descriptions of the C+LV association are used. The soil rating for the cambisoils, as referred before, is S = 3, 5 or 6. The latosoils granulometric analysis classify these as sandy clay loam (S = 5). Thus, as no other information was obtained the Lj soil association is assigned the rating S = 5.

Finally, the association Lv + Li + gr ("Latossol Vermelho Amarelo-Orto" and Litosoil phase granitic-gnaissic substratum), as understandable from the descriptions above is a mixture of the soil ratings S = 5 (for the latosoils) and S = 10 (for the litosoils). For this association an average rating of S = 8 is assigned.

Fig. 16 shows the map with the soil media rating.

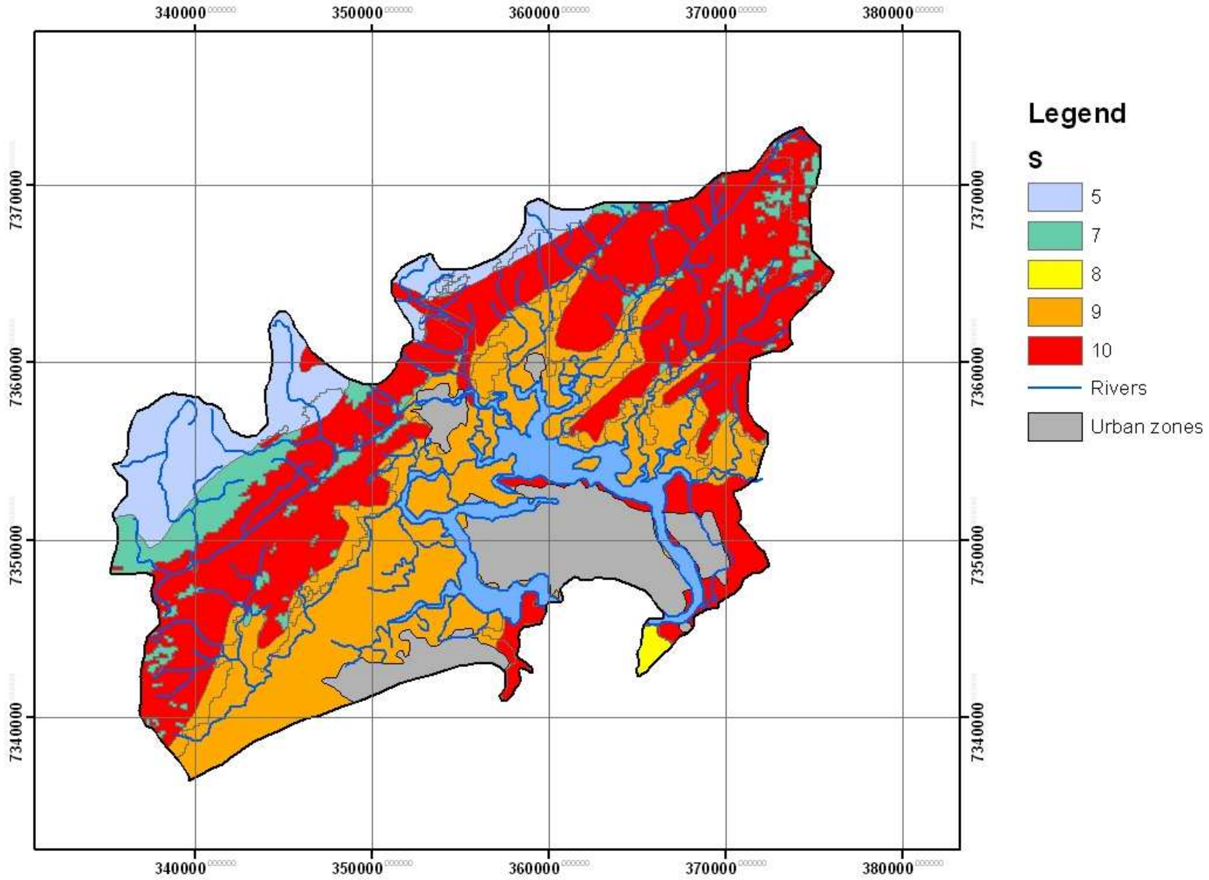


Fig. 16 – Characterisation of the Soil media (S)

3.4.5 Topography (T)

The slope map was computed using the information of the digital elevation model presented in Fig. 2 and is presented in Fig. 17.

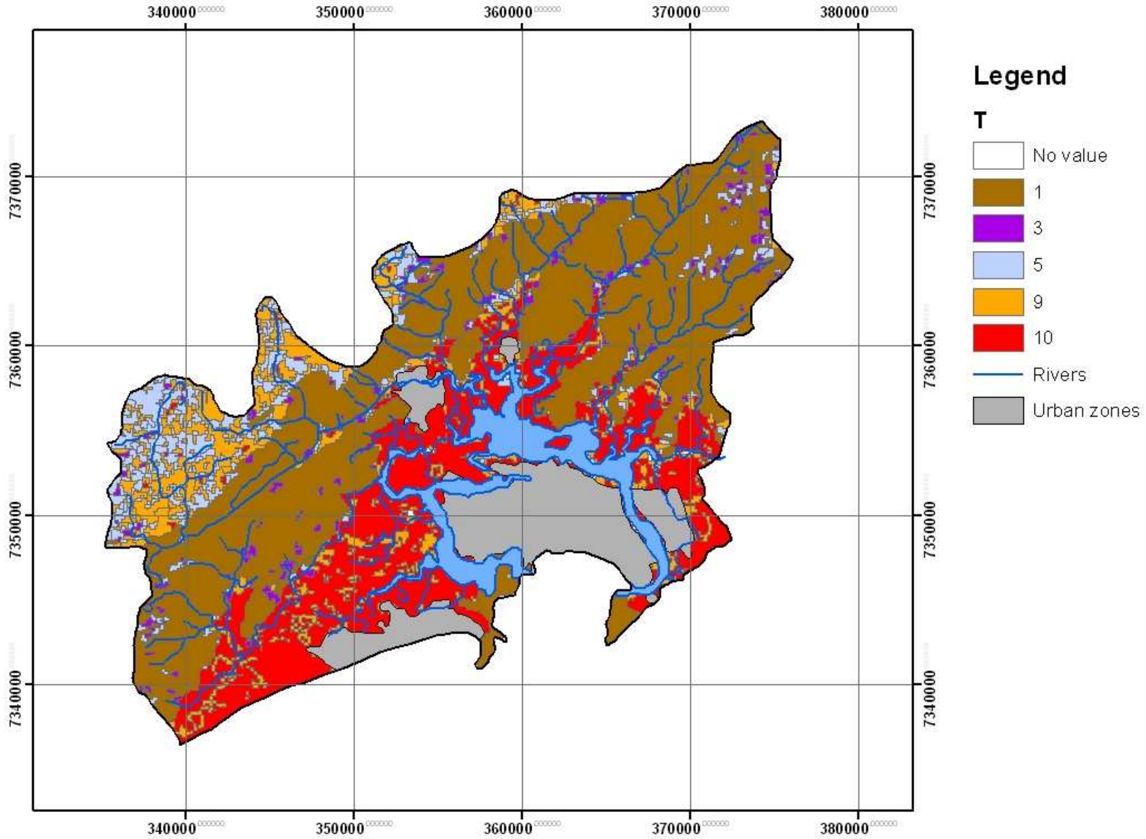


Fig. 17 – Characterisation of the Topography (T)

3.4.6 Impact of the vadose zone media (I)

For the characterisation of the impact of the vadose zone media one very important source of information would be well logs or geological cross sections. However the only available information is the geological description presented in section 1.2. Hence the I parameter was characterised based only on the geological map (Fig. 3) and on Table 15. All metamorphic and igneous formations were assigned a rating I = 4. The cenozoic formations due to the occurrence of some clayey layers (inside the sandy formations) were assigned a rating I = 6. The map with the characterisation of this parameter is shown in Fig. 18.

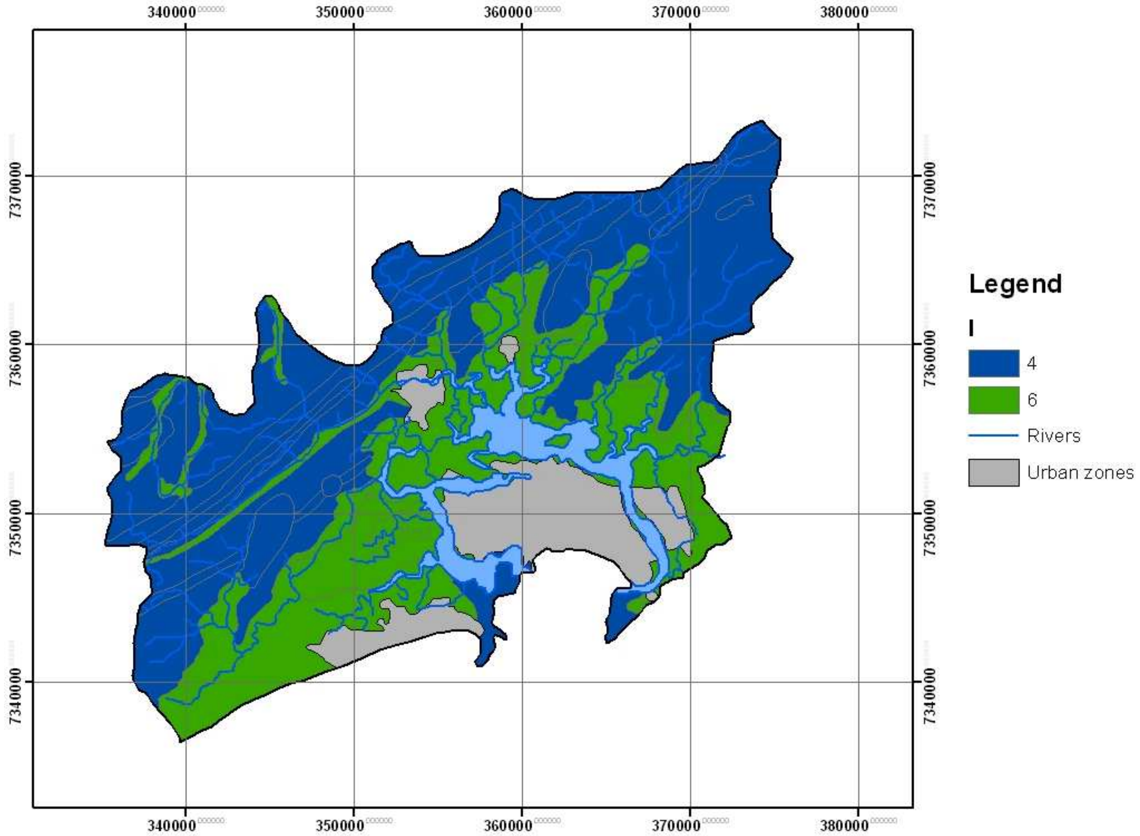


Fig. 18 – Characterisation of the Impact of the vadose zone media (I)

3.4.7 Hydraulic Conductivity of the aquifer (C)

For the characterisation of the C parameter the main source of information on hydraulic conductivity (K) is pumping test analysis. So far this data is not available for the EcoManage Project. It is not foreseen in the framework of this Project to carry out pumping tests. However if there is pumping tests data (pump discharge, time, drawdown) not interpreted, this data can be used to determine the hydraulic conductivity of the geological formations around the tested wells.

Another approach may use the pumping rate and the associated drawdown together with the well properties to approximate the hydraulic conductivity. Also this information is not yet available.

In the absence of this data, it remains the geological approach to estimate the hydraulic conductivity of the geological formations. This is based in statistical information that reports the range of hydraulic conductivity values as a function of the lithology. Tables or graphs (for instance Freeze and Cherry, 1979) provide this relation. This approach was used in the study area. The metamorphic and igneous formations were assigned a rating C = 1 (K < 4.1 m/d). For the cenozoic formations, due to their sand content, a value of C = 2 (4.1 m/d ≤ K < 12.2 m/d) was used. The C parameter map is shown in Fig. 19.

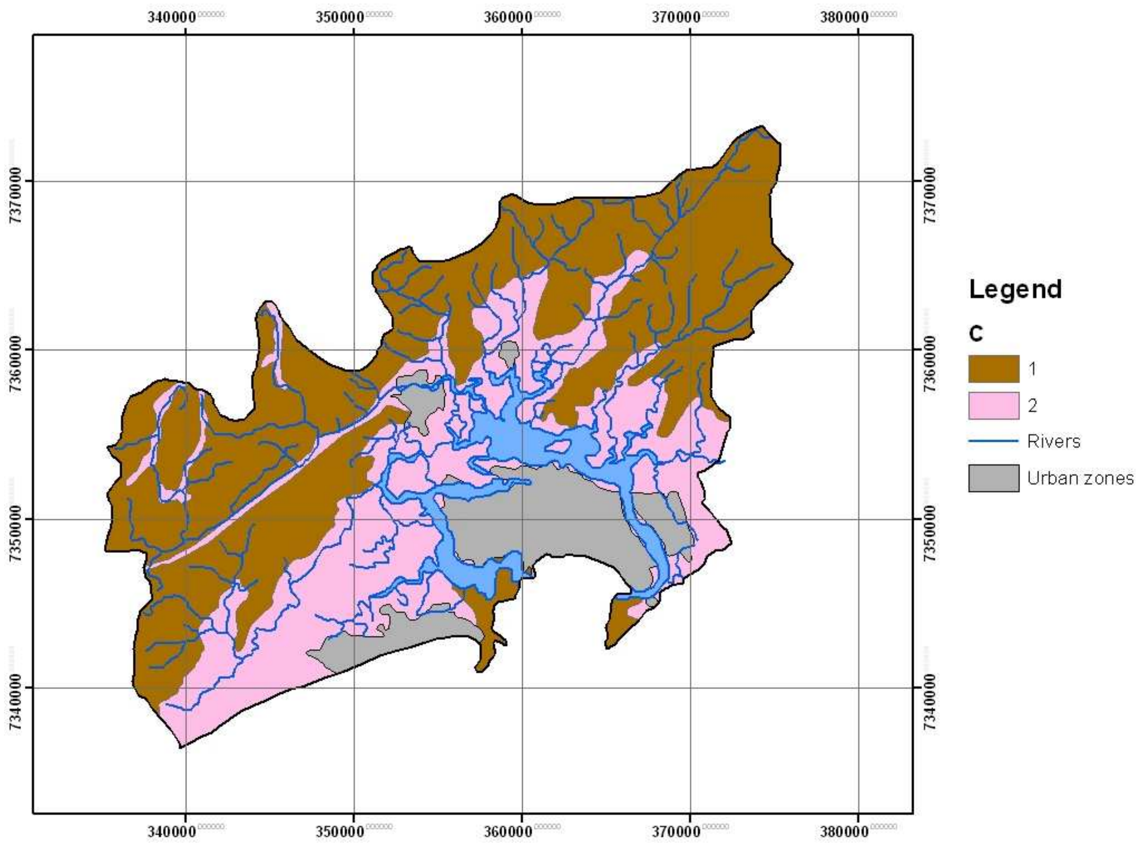


Fig. 19 – Characterisation of the Hydraulic Conductivity of the aquifer (C)

3.4.8 DRASTIC vulnerability of groundwater to pollution

The information of each parameter was gathered in the DRASTIC index. The result is shown in the map of Fig. 20. The DRASTIC vulnerability index distribution is also shown in Table 18 per index class. The area shows values between 117 and 176 (for a possible range from 23 to 226), which in relation to the maximum possible value of 100 % (DRASTIC = 226) is between 46 % and 75 % indicating low/medium to high vulnerability. The average DRASTIC index is 152 (medium vulnerability).

The high vulnerability class (values above 160) are located in the cenozoic formations aquifers. The medium (120 ≤ DRASTIC ≤ 159) and low (DRASTIC < 120) vulnerability classes occur associated to the metamorphic and igneous formations.

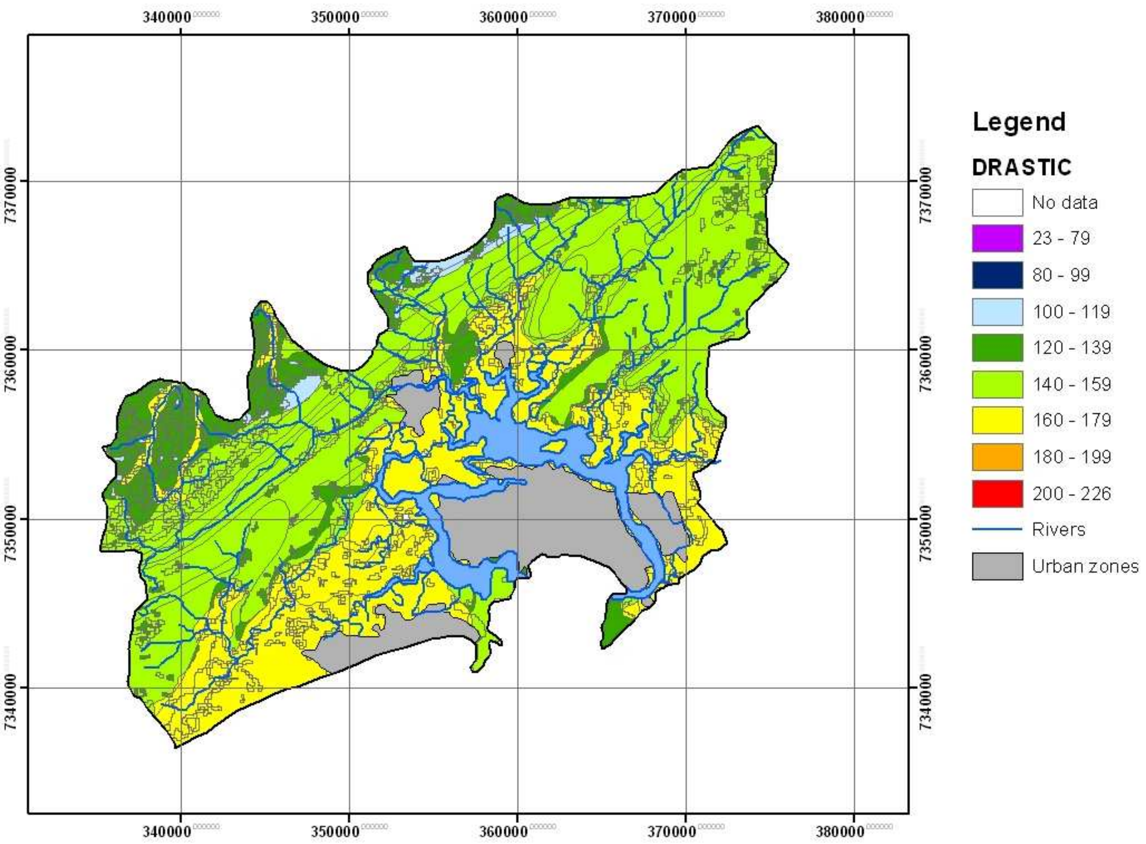


Fig. 20 – Characterisation of the DRASTIC vulnerability of groundwater to pollution

Table 18 – Distribution of DRASTIC ratings in the Land Santos Estuary area

DRASTIC index class	Vulnerability	Area (km^2)
100 - 119	Low	10.5
120 - 139	Medium	83.0
140 - 159		344.3
160 - 179	High	330.4

4 Conclusions

This Deliverable presents the characterisation of the groundwater properties of the Land Santos Estuary area. The work produced reflects the very few available information for this Project. This lack of data may be justified probably due to the physiography of the area, that conditions the land use, with human presence in very well located areas and almost inexistence of population outside the cities. Also the large amounts of rainfall, which imply the availability of water, at least in quantity, may be responsible for the inexistence of groundwater studies. The main concerns in the area may be pollution problems due to industry development and urban sewage.

The available information exists in small scale and is not adequate for the objectives of this Groundwater Task. Nevertheless some studies were carried out based on the 1:500 000 scale maps of geology and soils. This information has been interpreted together with precipitation data and altimetry data in order to produce the DRASTIC groundwater vulnerability mapping of the area. This map has been produced in Arc Info/Arc Map geographical information system. The results showed that DRASTIC index is between 117 and 176, indicating low/medium to high vulnerability, with an average value of 152. The high vulnerability class is associated to the cenozoic formations sedimentary aquifers while the low/medium vulnerability classes are associated to the basement formations.

Groundwater recharge has been estimated using the hydrograph separation technique. The methodology behind this technique did not prove to be the most adequate as rainfall amounts are very large and do not allow for the best application of the technique. Obtained values were about 900 mm/yr for precipitations in the order of around 3300 mm/yr.

As far as potential evapotranspiration, land use and soil information are available for the area, a daily sequential water balance model may be used to estimate recharge.

Present work should be improved if more detailed cartographic information becomes available (in terms of soils, geology and land use) and also if hydrogeological information is obtained (inventory of wells, piezometry, lithological logs, quality data, hydraulic parameters – transmissivity, hydraulic conductivity, storage). This hydrogeological information may be obtained (at least partially) if some fieldwork is carried out. However, this fieldwork should be performed only to complement existing information instead of obtaining completely new information.

Concerning the other two areas of the EcoManage project (Aisén Fjord in Chile, and Bahía Blanca in Argentina) information about groundwater is still not available and for this reason could not be incorporated in this Deliverable 2.6. Further reports complementing this Deliverable 2.6 will be produced as far as this information is available and treated. For this reason this Deliverble 2.6 is sub-titled "1st Version – The Santos Estuary area".

Lisboa, Laboratório Nacional de Engenharia Civil, December 2005

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Annex 1 – Separation of surface flow into direct runoff and base flow for the Mogi watershed

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
1	01-08-1972	01-08-1972	16-08-1972	100.0000	0	5.6	5.6	0.0	128.1
2	15-08-1972	15-08-1972	25-08-1972	100.0000	8.2	29.2	5.7	23.5	35.8
3	24-08-1972	24-08-1972	30-08-1972	100.0000	12.1	30.1	18.2	11.9	2
4	29-08-1972	30-08-1972	22-09-1972	100.0000	8	73.2	6.4	66.8	22.8
5	21-09-1972	24-09-1972	29-09-1972	1.3923	127.4	63.9	63.6	0.4	0
6	25-09-1972	26-09-1972	29-09-1972	100.0000	6.3	13.9	13.9	0.0	0
7	28-09-1972	01-10-1972	12-10-1972	0.6678	123.5	85.3	79.3	6.0	0
8	03-10-1972	04-10-1972	13-10-1972	0.8814	65.6	64.3	58.7	5.7	0
9	05-10-1972	06-10-1972	15-10-1972	0.8594	78.3	50.8	47.3	3.5	0
10	07-10-1972	10-10-1972	12-10-1972	6.3710	121.5	112.6	112.6	0.0	0
11	11-10-1972	12-10-1972	16-10-1972	100.0000	55.1	67.1	67.1	0.0	0
12	15-10-1972	17-10-1972	26-10-1972	100.0000	106.5	146.5	81.6	64.9	7.2
13	25-10-1972	25-10-1972	29-10-1972	100.0000	8.1	19.9	19.9	0.0	0
14	28-10-1972	30-10-1972	29-11-1972	0.2309	63.8	70.2	33.9	36.3	7.2
15	02-11-1972	07-11-1972	10-11-1972	100.0000	143.7	163.9	163.9	0.0	0
16	09-11-1972	13-11-1972	15-11-1972	100.0000	30.4	50.9	50.9	0.0	0
17	14-11-1972	17-11-1972	19-11-1972	100.0000	63.2	203.8	203.8	0.0	0
18	18-11-1972	22-11-1972	03-12-1972	100.0000	71.7	472.6	256.8	215.8	10.9
19	02-12-1972	05-12-1972	13-12-1972	0.9413	52.9	52.5	48.1	4.4	0
20	07-12-1972	11-12-1972	13-12-1972	100.0000	11.1	24.8	24.8	0.0	0
21	12-12-1972	14-12-1972	20-12-1972	100.0000	55	47.3	24.6	22.7	0
22	19-12-1972	21-12-1972	24-12-1972	6.6567	24.6	24.6	24.6	0.0	0
23	23-12-1972	24-12-1972	31-12-1972	100.0000	35.6	44.3	21.6	22.7	0
24	30-12-1972	31-12-1972	06-01-1973	100.0000	10	33.0	13.8	19.2	18.3
25	05-01-1973	05-01-1973	09-01-1973	100.0000	1.7	12.1	12.1	0.0	5
26	08-01-1973	09-01-1973	11-01-1973	100.0000	8.1	9.1	9.1	0.0	0
27	10-01-1973	12-01-1973	16-01-1973	100.0000	60.8	18.6	18.6	0.0	0
28	15-01-1973	19-01-1973	28-01-1973	0.7838	232.3	148.4	143.9	4.5	0
29	20-01-1973	22-01-1973	24-01-1973	6.4515	43.1	40.7	40.7	0.0	0
30	23-01-1973	24-01-1973	03-02-1973	0.7055	23.9	23.6	20.1	3.5	0
31	25-01-1973	26-01-1973	02-02-1973	100.0000	79.3	98.1	61.6	36.5	18.7
32	01-02-1973	02-02-1973	06-02-1973	100.0000	11.5	24.3	24.3	0.0	0
33	05-02-1973	08-02-1973	25-02-1973	0.1799	133.1	110.7	66.0	44.7	0
34	11-02-1973	16-02-1973	25-02-1973	0.5035	145	116.5	96.3	20.2	0
35	17-02-1973	19-02-1973	25-02-1973	0.1927	67.7	54.5	35.5	18.9	0
36	20-02-1973	24-02-1973	31-03-1973	100.0000	7.6	15.8	15.8	0.0	242.6
37	30-03-1973	03-04-1973	07-04-1973	100.0000	15.2	25.8	25.8	0.0	0
38	06-04-1973	11-04-1973	28-04-1973	0.4869	272.5	187.7	149.4	38.3	0
39	12-04-1973	13-04-1973	16-04-1973	100.0000	13.8	39.2	39.2	0.0	0
40	15-04-1973	16-04-1973	20-04-1973	100.0000	25.2	43.3	43.3	0.0	0
41	19-04-1973	21-04-1973	20-05-1973	0.2494	109	79.5	39.0	40.4	0
42	24-04-1973	25-04-1973	17-05-1973	0.2589	13.5	13.3	5.2	8.1	0
43	27-04-1973	04-05-1973	22-05-1973	0.4248	134.3	100.5	67.6	32.9	0
44	07-05-1973	09-05-1973	15-05-1973	1.1527	138.4	36.7	36.1	0.5	0
45	10-05-1973	12-05-1973	13-06-1973	0.2136	54.2	54.3	17.3	36.9	0.4
46	15-05-1973	17-05-1973	13-06-1973	0.1966	23.1	13.7	5.5	8.2	0
47	18-05-1973	24-05-1973	15-06-1973	0.3172	85.7	55.2	29.7	25.5	48
48	27-05-1973	02-06-1973	06-06-1973	100.0000	0.8	56.0	56.0	0.0	0.4
49	05-06-1973	05-06-1973	16-06-1973	100.0000	0.1	50.4	11.6	38.9	2
50	15-06-1973	17-06-1973	03-08-1973	0.1214	71	46.1	24.2	22.0	0
51	18-06-1973	23-06-1973	26-06-1973	100.0000	4.8	9.4	9.4	0.0	0
52	25-06-1973	28-06-1973	09-07-1973	0.5449	19.9	14.4	11.8	2.6	0
53	29-06-1973	05-07-1973	31-07-1973	0.2199	48.2	27.4	15.3	12.1	0
54	06-07-1973	07-07-1973	14-07-1973	100.0000	0.9	10.3	2.1	8.1	0
55	13-07-1973	22-07-1973	28-07-1973	1.1096	117.9	49.7	47.9	1.8	0
56	23-07-1973	26-07-1973	16-08-1973	0.2943	76.5	51.3	38.7	12.6	0
57	27-07-1973	30-07-1973	13-08-1973	100.0000	37.7	77.8	24.2	53.6	15.2
58	12-08-1973	17-08-1973	22-08-1973	100.0000	13.5	25.3	11.2	14.1	2.8
59	21-08-1973	25-08-1973	10-09-1973	0.3903	63.9	47.0	36.7	10.3	0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
60	26-08-1973	01-09-1973	17-09-1973	0.4428	63	62.6	41.7	20.9	0
61	02-09-1973	11-09-1973	13-09-1973	100.0000	73.3	85.9	85.9	0.0	0
62	12-09-1973	17-09-1973	19-09-1973	100.0000	31.4	37.8	37.8	0.0	0
63	18-09-1973	19-09-1973	21-09-1973	100.0000	3.4	11.9	11.9	0.0	0
64	20-09-1973	21-09-1973	28-09-1973	1.2122	109	105.2	101.3	3.8	0
65	22-09-1973	28-09-1973	30-09-1973	100.0000	103.8	151.8	151.8	0.0	0
66	29-09-1973	30-09-1973	14-10-1973	0.5031	34.9	34.6	25.0	9.6	0
67	01-10-1973	02-10-1973	10-10-1973	100.0000	18.3	64.8	21.3	43.5	4.1
68	09-10-1973	12-10-1973	22-10-1973	0.7046	41.9	41.5	35.8	5.7	0
69	13-10-1973	15-10-1973	19-10-1973	100.0000	91.1	106.4	106.4	0.0	0
70	18-10-1973	20-10-1973	25-10-1973	100.0000	28.3	52.4	26.3	26.1	0
71	24-10-1973	29-10-1973	31-10-1973	100.0000	96.0	97.1	97.1	0.0	0
72	30-10-1973	31-10-1973	02-11-1973	100.0000	11.7	34.2	34.2	0.0	0
73	01-11-1973	04-11-1973	09-11-1973	100.0000	131.3	152.3	104.7	47.7	1.8
74	08-11-1973	08-11-1973	13-11-1973	100.0000	0.1	49.5	21.6	27.9	10
75	12-11-1973	13-11-1973	15-11-1973	100.0000	4.5	21.5	21.5	0.0	0
76	14-11-1973	15-11-1973	23-12-1973	0.1828	95	94.0	48.7	45.3	0
77	18-11-1973	20-11-1973	27-02-1974	0.0645	139.3	136.5	51.3	85.1	0
78	25-11-1973	26-11-1973	07-12-1973	0.6791	73.5	66.0	58.5	7.5	0
79	28-11-1973	29-11-1973	04-12-1973	100.0000	41.8	46.9	23.3	23.6	0
80	03-12-1973	05-12-1973	07-12-1973	100.0000	23.6	37.3	37.3	0.0	0
81	06-12-1973	10-12-1973	12-12-1973	100.0000	30.4	47.8	47.8	0.0	0
82	11-12-1973	14-12-1973	17-12-1973	100.0000	4.4	44.2	44.2	0.0	0
83	16-12-1973	19-12-1973	27-12-1973	0.8570	45.2	44.8	42.5	2.4	0
84	20-12-1973	22-12-1973	01-02-1974	0.1683	140.6	144.1	93.1	51.0	5.7
85	25-12-1973	27-12-1973	09-01-1974	0.5014	30.9	24.2	18.6	5.6	0
86	28-12-1973	03-01-1974	08-01-1974	100.0000	73.1	96.9	58.0	38.9	2.5
87	07-01-1974	08-01-1974	11-01-1974	6.6242	27.1	26.5	26.5	0.0	0
88	10-01-1974	13-01-1974	26-01-1974	0.5684	108.8	86.9	74.2	12.8	0
89	14-01-1974	20-01-1974	29-01-1974	100.0000	250.5	380.2	238.3	141.8	67.1
90	28-01-1974	31-01-1974	02-02-1974	100.0000	35.1	59.1	59.1	0.0	0
91	01-02-1974	03-02-1974	07-02-1974	100.0000	28.4	51.7	51.7	0.0	0
92	06-02-1974	08-02-1974	12-02-1974	100.0000	0.2	40.8	40.8	0.0	0
93	11-02-1974	12-02-1974	16-02-1974	100.0000	0.2	28.6	28.6	0.0	0.6
94	15-02-1974	18-02-1974	20-02-1974	100.0000	9.5	27.8	27.8	0.0	0
95	19-02-1974	19-02-1974	22-02-1974	100.0000	7.7	13.0	13.0	0.0	0
96	21-02-1974	22-02-1974	30-03-1974	0.1801	71.7	45.1	15.9	29.2	0
97	23-02-1974	25-02-1974	27-02-1974	100.0000	9.9	10.6	10.6	0.0	0
98	26-02-1974	26-02-1974	16-03-1974	0.5564	40	35.9	8.6	27.3	0
99	06-03-1974	08-03-1974	06-04-1974	0.2194	36.9	36.7	15.5	21.2	0
100	10-03-1974	13-03-1974	25-03-1974	0.5645	92.3	34.4	27.7	6.7	0
101	14-03-1974	15-03-1974	31-03-1974	0.4398	19.9	19.7	9.0	10.8	0
102	18-03-1974	20-03-1974	22-03-1974	6.3468	92.8	78.8	78.8	0.0	0
103	21-03-1974	28-03-1974	03-04-1974	100.0000	118.7	262.8	220.1	42.7	0.3
104	02-04-1974	08-04-1974	11-04-1974	100.0000	58.2	65.5	65.5	0.0	0
105	10-04-1974	14-04-1974	20-04-1974	100.0000	22.2	40.2	18.4	21.7	0
106	19-04-1974	23-04-1974	31-05-1974	0.1555	51.3	51.4	28.5	22.9	0
107	24-04-1974	27-04-1974	02-05-1974	1.5298	86.8	32.7	32.5	0.2	0
108	28-04-1974	29-04-1974	06-05-1974	0.9942	13.1	12.8	12.0	0.8	0
109	30-04-1974	01-05-1974	03-05-1974	100.0000	3.7	6.8	6.8	0.0	0
110	02-05-1974	03-05-1974	07-05-1974	100.0000	0.5	22.4	22.4	0.0	0
111	06-05-1974	07-05-1974	09-05-1974	6.3815	19.7	17.3	17.3	0.0	0
112	08-05-1974	10-05-1974	12-05-1974	100.0000	10.7	21.2	21.2	0.0	0
113	11-05-1974	11-05-1974	14-05-1974	100.0000	0.3	11.5	11.5	0.0	0
114	13-05-1974	16-05-1974	22-05-1974	100.0000	1.4	41.5	17.0	24.4	0
115	21-05-1974	25-05-1974	31-05-1974	100.0000	0.2	38.1	16.5	21.6	0.1
116	30-05-1974	31-05-1974	08-06-1974	100.0000	7.6	28.5	7.5	21.0	1.4
117	07-06-1974	08-06-1974	15-06-1974	1.0468	13.8	13.5	12.0	1.5	0
118	10-06-1974	15-06-1974	20-07-1974	0.1799	63.3	63.1	33.7	29.4	0
119	18-06-1974	20-06-1974	28-06-1974	0.6943	6.2	6.1	5.3	0.8	0
120	21-06-1974	24-06-1974	29-06-1974	1.1933	90.4	42.3	41.9	0.4	0
121	25-06-1974	27-06-1974	12-07-1974	0.4375	35.7	35.3	27.3	7.9	0
122	28-06-1974	29-06-1974	03-07-1974	100.0000	9.6	10.6	10.6	0.0	0.2
123	02-07-1974	06-07-1974	09-07-1974	100.0000	0.1	21.2	21.2	0.0	0
124	08-07-1974	15-07-1974	18-07-1974	100.0000	0.3	30.7	30.7	0.0	0
125	17-07-1974	22-07-1974	24-07-1974	100.0000	11.2	21.1	21.1	0.0	0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
126	23-07-1974	25-07-1974	30-07-1974	1.3913	101.1	70.7	70.3	0.4	0
127	26-07-1974	27-07-1974	10-08-1974	100.0000	3.1	57.1	11.3	45.8	0
128	09-08-1974	10-08-1974	17-08-1974	100.0000	21.7	26.6	9.1	17.5	0.2
129	16-08-1974	18-08-1974	14-09-1974	0.2232	30.6	30.4	14.9	15.5	0
130	19-08-1974	27-08-1974	30-08-1974	100.0000	2.8	20.8	20.8	0.0	0
131	29-08-1974	05-09-1974	18-09-1974	0.5574	118.7	96.7	81.4	15.3	0
132	06-09-1974	07-09-1974	16-09-1974	0.8465	64.7	57.2	52.6	4.7	0
133	09-09-1974	10-09-1974	21-09-1974	100.0000	13.5	46.8	11.1	35.7	1.1
134	20-09-1974	22-09-1974	28-09-1974	100.0000	8.6	28.8	11.1	17.7	1.5
135	27-09-1974	03-10-1974	12-10-1974	0.8611	135.4	129.2	121.5	7.7	0
136	04-10-1974	05-10-1974	20-10-1974	100.0000	25	83.8	20.3	63.5	4.3
137	19-10-1974	20-10-1974	25-10-1974	1.4568	30.4	22.6	22.5	0.2	0
138	21-10-1974	24-10-1974	26-10-1974	6.4521	21.4	19.7	19.7	0.0	0
139	25-10-1974	27-10-1974	31-10-1974	0.5139	29.4	28.1	22.6	5.5	0
140	28-10-1974	31-10-1974	31-10-1974	0.5139	108.1	80.8	58.8	22.0	0

Annex 2 – Separation of surface flow into direct runoff and base flow for the Quilombo watershed

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
1	01-10-1971	00-01-1900	24-11-1971	0.4252	0.0	57.9	0.0	57.9	228.9
2	12-11-1971	14-11-1971	22-12-1971	0.1359	22.2	17.4	6.8	10.7	0.0
3	16-11-1971	22-11-1971	06-12-1971	0.4351	70.5	21.8	14.3	7.5	0.0
4	23-11-1971	24-11-1971	08-12-1971	0.3898	16.6	10.0	6.6	3.5	0.0
5	25-11-1971	29-11-1971	11-01-1972	0.1291	28.0	27.8	7.9	19.9	0.0
6	30-11-1971	04-12-1971	02-01-1972	0.1741	34.9	15.1	6.9	8.2	0.0
7	05-12-1971	06-12-1971	22-12-1971	0.3150	68.1	8.9	5.6	3.3	0.0
8	08-12-1971	12-12-1971	03-01-1972	0.2285	10.4	10.4	5.0	5.4	0.0
9	13-12-1971	17-12-1971	29-12-1971	0.7465	152.2	56.0	35.0	21.1	0.0
10	22-12-1971	26-12-1971	29-02-1972	0.0929	147.7	61.8	18.7	43.0	0.0
11	27-12-1971	29-12-1971	25-01-1972	0.1939	28.2	10.3	2.8	7.6	4.5
12	02-01-1972	08-01-1972	15-01-1972	0.8220	49.6	9.4	8.5	0.9	0.0
13	09-01-1972	11-01-1972	08-05-1972	0.0451	51.3	50.4	5.9	44.5	0.0
14	13-01-1972	14-01-1972	20-01-1972	100.0000	0.1	1.5	0.6	0.9	0.0
15	19-01-1972	25-01-1972	05-04-1972	0.0872	220.0	119.0	61.5	57.5	28.8
16	30-01-1972	01-02-1972	09-02-1972	0.5537	23.4	4.4	3.9	0.5	0.0
17	02-02-1972	05-02-1972	08-04-1972	0.0848	68.7	60.0	37.3	22.7	0.0
18	08-02-1972	11-02-1972	14-03-1972	0.1344	41.5	13.3	8.0	5.3	0.0
19	12-02-1972	15-02-1972	18-02-1972	2.1575	96.2	30.7	30.7	0.0	0.0
20	16-02-1972	17-02-1972	20-02-1972	100.0000	10.2	10.3	10.3	0.0	0.0
21	19-02-1972	22-02-1972	23-03-1972	0.2393	134.9	138.0	100.2	37.8	3.3
22	27-02-1972	01-03-1972	07-06-1972	0.0597	73.6	71.9	14.3	57.6	0.0
23	02-03-1972	15-03-1972	27-07-1972	0.0451	134.3	135.2	23.9	111.4	0.0
24	18-03-1972	24-03-1972	21-04-1972	0.1641	13.9	8.6	2.4	6.1	0.0
25	26-03-1972	27-03-1972	03-04-1972	0.7402	25.0	3.4	2.8	0.7	0.0
26	29-03-1972	03-04-1972	20-04-1972	0.3377	75.6	22.8	16.0	6.8	0.0
27	04-04-1972	08-04-1972	05-05-1972	0.2222	98.7	45.9	28.6	17.2	0.0
28	09-04-1972	11-04-1972	15-05-1972	0.1580	18.2	17.9	5.6	12.4	0.0
29	12-04-1972	18-04-1972	13-05-1972	0.2311	56.4	32.3	18.5	13.8	0.0
30	19-04-1972	25-04-1972	29-04-1972	100.0000	0.4	21.0	21.0	0.0	0.0
31	28-04-1972	01-05-1972	08-05-1972	100.0000	1.2	30.2	9.5	20.7	0.0
32	07-05-1972	09-05-1972	15-05-1972	100.0000	8.4	21.1	8.1	13.0	0.0
33	14-05-1972	17-05-1972	20-05-1972	100.0000	0.3	14.3	14.3	0.0	0.0
34	19-05-1972	20-05-1972	05-08-1972	0.0762	54.6	51.4	10.0	41.5	0.0
35	23-05-1972	26-05-1972	08-06-1972	0.4153	22.0	7.5	3.8	3.7	0.0
36	29-05-1972	03-06-1972	15-06-1972	100.0000	0.3	55.7	40.2	15.5	0.2
37	14-06-1972	15-06-1972	21-06-1972	1.1310	5.2	5.1	4.6	0.5	0.0
38	17-06-1972	19-06-1972	06-07-1972	100.0000	6.7	26.8	3.6	23.2	0.0
39	05-07-1972	06-07-1972	31-07-1972	0.2267	11.9	11.9	3.4	8.4	0.0
40	10-07-1972	19-07-1972	27-08-1972	0.1307	43.5	20.3	6.3	14.0	0.0
41	22-07-1972	28-07-1972	20-09-1972	0.0949	33.0	20.0	2.8	17.1	0.0
42	04-08-1972	11-08-1972	27-08-1972	0.3075	111.5	35.3	31.6	3.7	0.0
43	12-08-1972	16-08-1972	24-09-1972	0.1352	24.8	16.4	2.9	13.5	0.0
44	21-08-1972	24-08-1972	08-09-1972	0.3718	47.9	10.7	6.8	4.0	0.0
45	27-08-1972	06-09-1972	10-10-1972	0.1568	20.3	20.2	4.2	16.0	0.0
46	11-09-1972	15-09-1972	24-10-1972	0.1121	11.4	9.4	2.2	7.2	0.0
47	16-09-1972	19-09-1972	22-09-1972	100.0000	1.1	1.5	1.5	0.0	0.0
48	21-09-1972	26-09-1972	11-10-1972	0.3691	133.7	27.8	23.2	4.6	0.0
49	28-09-1972	01-10-1972	19-10-1972	0.3385	123.5	36.7	29.3	7.5	0.0
50	03-10-1972	04-10-1972	30-11-1972	0.1144	65.6	62.6	14.0	48.6	0.0
51	05-10-1972	07-10-1972	15-10-1972	0.5523	88.3	10.1	9.5	0.7	0.0
52	08-10-1972	10-10-1972	19-10-1972	0.6915	111.5	27.8	25.5	2.3	0.0
53	11-10-1972	12-10-1972	31-10-1972	0.3229	55.1	21.6	13.4	8.2	0.0
54	14-10-1972	17-10-1972	12-04-1973	0.0320	106.5	120.6	19.9	100.7	15.3
55	26-10-1972	30-10-1972	09-01-1973	0.0666	63.8	24.0	7.4	16.6	7.2
56	02-11-1972	07-11-1972	22-12-1972	0.1244	143.7	58.7	37.4	21.3	0.0
57	09-11-1972	11-11-1972	21-11-1972	0.4906	21.4	5.5	4.3	1.2	0.0
58	12-11-1972	18-11-1972	07-02-1973	0.0657	77.2	42.8	9.6	33.2	0.0
59	19-11-1972	22-11-1972	20-01-1973	0.0871	66.7	27.9	8.4	19.4	0.0
60	26-11-1972	27-11-1972	19-12-1972	0.1610	4.4	2.5	0.8	1.7	0.0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
61	29-11-1972	05-12-1972	24-12-1972	0.2472	59.4	12.3	7.6	4.7	0.0
62	06-12-1972	08-12-1972	06-01-1973	0.1686	9.3	9.3	2.9	6.4	0.0
63	10-12-1972	14-12-1972	05-01-1973	0.2425	56.8	13.3	6.9	6.4	0.0
64	16-12-1972	21-12-1972	28-12-1972	0.8266	24.6	10.5	9.7	0.7	0.0
65	22-12-1972	24-12-1972	20-02-1973	0.0979	35.6	35.6	8.2	27.4	0.0
66	29-12-1972	31-12-1972	17-02-1973	0.0906	10.0	9.9	1.8	8.1	0.0
67	02-01-1973	04-01-1973	15-01-1973	0.3919	18.3	3.4	2.3	1.1	0.0
68	05-01-1973	10-01-1973	03-03-1973	0.0949	19.4	19.2	3.8	15.3	0.0
69	11-01-1973	12-01-1973	17-01-1973	1.0173	56.2	1.2	1.1	0.1	0.0
70	14-01-1973	19-01-1973	01-02-1973	0.5150	232.3	163.9	156.8	7.1	0.0
71	20-01-1973	22-01-1973	27-02-1973	0.1696	43.1	35.7	14.6	21.1	0.0
72	23-01-1973	26-01-1973	14-03-1973	0.1335	103.2	52.2	15.8	36.5	13.3
73	30-01-1973	02-02-1973	05-03-1973	0.1692	16.9	15.1	5.0	10.1	0.0
74	03-02-1973	08-02-1973	12-04-1973	0.0720	133.1	77.2	18.9	58.3	0.0
75	13-02-1973	16-02-1973	24-02-1973	0.7033	145.0	13.9	12.3	1.6	0.0
76	17-02-1973	19-02-1973	09-03-1973	0.3202	67.7	19.5	12.4	7.1	0.0
77	20-02-1973	24-02-1973	01-03-1973	100.0000	7.6	18.7	6.4	12.3	0.0
78	28-02-1973	02-03-1973	05-03-1973	100.0000	2.0	11.2	11.2	0.0	0.0
79	04-03-1973	06-03-1973	12-04-1973	0.1021	91.0	44.1	13.3	30.7	0.0
80	08-03-1973	10-03-1973	22-03-1973	0.5331	55.3	12.6	8.3	4.3	0.0
81	13-03-1973	14-03-1973	20-03-1973	1.0012	18.2	7.2	6.9	0.3	0.0
82	15-03-1973	21-03-1973	23-03-1973	100.0000	5.5	14.9	14.9	0.0	0.0
83	22-03-1973	26-03-1973	12-04-1973	0.0600	70.6	51.0	15.4	35.6	0.0
84	30-03-1973	01-04-1973	12-04-1973	0.0757	13.9	7.6	2.0	5.6	0.0
85	02-04-1973	03-04-1973	08-04-1973	100.0000	1.3	3.1	2.5	0.6	0.0
86	07-04-1973	13-04-1973	25-02-1974	0.0222	286.3	207.2	16.4	190.8	632.5
87	02-06-1973	05-06-1973	13-06-1973	0.7525	0.6	0.5	0.3	0.2	0.7
88	12-06-1973	13-06-1973	04-07-1973	0.1305	1.3	1.2	0.3	0.9	0.0
89	14-06-1973	17-06-1973	26-06-1973	0.5586	71.0	8.0	7.0	0.9	0.0
90	18-06-1973	19-06-1973	23-07-1973	0.1099	4.8	4.7	1.7	3.0	0.0
91	24-06-1973	26-06-1973	30-06-1973	0.9577	9.0	1.3	1.2	0.1	0.0
92	27-06-1973	28-06-1973	02-07-1973	0.9171	10.9	1.5	1.4	0.1	0.0
93	29-06-1973	05-07-1973	25-07-1973	0.2238	48.2	9.5	6.0	3.5	0.0
94	06-07-1973	07-07-1973	19-07-1973	100.0000	0.9	6.2	0.3	5.9	0.0
95	18-07-1973	22-07-1973	29-07-1973	0.9012	117.9	24.0	22.8	1.2	0.0
96	23-07-1973	26-07-1973	25-09-1973	0.0894	76.5	37.8	12.7	25.1	0.0
97	28-07-1973	29-07-1973	02-08-1973	1.4322	37.5	4.8	4.8	0.0	0.0
98	30-07-1973	31-07-1973	03-08-1973	100.0000	0.2	2.6	2.6	0.0	0.0
99	02-08-1973	03-08-1973	09-09-1973	0.1261	3.0	9.4	2.1	7.3	6.5
100	06-08-1973	07-08-1973	06-09-1973	0.1728	5.7	7.9	0.6	7.2	2.2
101	13-08-1973	25-08-1973	20-02-1974	0.0287	78.0	75.1	8.8	66.3	0.0
102	27-08-1973	28-08-1973	03-09-1973	0.6184	15.4	1.6	1.3	0.2	0.0
103	29-08-1973	05-09-1973	19-10-1973	0.1088	63.7	23.7	12.2	11.6	0.0
104	07-09-1973	09-09-1973	13-09-1973	1.1239	55.3	4.8	4.7	0.1	0.0
105	10-09-1973	12-09-1973	14-09-1973	6.5249	2.3	2.1	2.1	0.0	0.0
106	13-09-1973	18-09-1973	27-10-1973	0.1261	34.1	19.3	8.1	11.2	0.0
107	19-09-1973	21-09-1973	02-10-1973	0.6181	109.3	23.2	19.1	4.2	0.0
108	22-09-1973	24-09-1973	07-10-1973	0.4699	93.2	26.7	22.7	4.0	0.0
109	25-09-1973	26-09-1973	28-09-1973	6.5897	3.5	3.3	3.3	0.0	0.0
110	27-09-1973	02-10-1973	05-11-1973	0.1808	60.3	38.2	12.1	26.1	0.0
111	06-10-1973	10-10-1973	30-11-1973	0.1029	24.5	23.5	5.0	18.5	0.0
112	11-10-1973	13-10-1973	21-11-1973	0.1284	29.1	14.4	4.3	10.2	0.0
113	14-10-1973	15-10-1973	30-10-1973	0.3401	83.5	10.2	7.1	3.1	0.0
114	17-10-1973	20-10-1973	15-01-1974	0.0648	28.3	44.6	4.4	40.2	16.8
115	26-10-1973	29-10-1973	07-12-1973	0.1470	79.2	34.4	14.3	20.1	0.0
116	30-10-1973	31-10-1973	02-11-1973	47.4215	11.7	3.9	3.9	0.0	0.0
117	01-11-1973	04-11-1973	07-11-1973	1.9408	131.3	16.1	16.1	0.0	0.0
118	05-11-1973	08-11-1973	12-11-1973	100.0000	1.9	13.2	13.2	0.0	0.0
119	11-11-1973	15-11-1973	11-01-1974	0.1045	109.5	48.9	13.1	35.8	0.0
120	18-11-1973	20-11-1973	26-12-1973	0.1671	139.3	38.2	17.0	21.2	0.0
121	24-11-1973	29-11-1973	28-01-1974	0.1066	115.3	61.4	9.2	52.2	22.9
122	05-12-1973	13-12-1973	30-12-1973	0.4408	35.5	31.6	5.0	26.6	29.0
123	18-12-1973	19-12-1973	05-02-1974	0.1056	16.2	16.0	3.3	12.7	0.0
124	20-12-1973	22-12-1973	30-12-1973	0.7735	140.6	16.4	15.1	1.3	0.0
125	23-12-1973	29-12-1973	19-01-1974	0.2901	38.0	38.0	24.4	13.6	0.0
126	30-12-1973	03-01-1974	07-03-1974	0.0965	71.7	71.4	24.9	46.5	0.0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
127	06-01-1974	08-01-1974	18-02-1974	0.1277	29.6	18.0	4.4	13.6	0.0
128	11-01-1974	14-01-1974	03-03-1974	0.1199	123.0	45.8	22.0	23.8	0.0
129	15-01-1974	17-01-1974	22-01-1974	1.6999	206.9	116.8	116.6	0.2	0.0
130	18-01-1974	20-01-1974	24-01-1974	100.0000	29.4	29.6	29.6	0.0	0.0
131	23-01-1974	24-01-1974	03-04-1974	0.0980	6.1	82.2	8.7	73.4	80.1
132	30-01-1974	31-01-1974	09-02-1974	0.4602	16.0	2.1	1.5	0.6	0.0
133	01-02-1974	03-02-1974	23-02-1974	0.3062	28.4	20.6	10.4	10.2	0.0
134	06-02-1974	08-02-1974	15-02-1974	100.0000	0.2	17.8	3.4	14.4	0.2
135	14-02-1974	15-02-1974	19-02-1974	100.0000	0.7	12.2	12.2	0.0	0.4
136	18-02-1974	19-02-1974	08-03-1974	0.3609	16.7	16.6	8.4	8.2	0.0
137	21-02-1974	28-02-1974	01-04-1974	0.2156	121.6	48.5	12.1	36.4	0.0
138	06-03-1974	15-03-1974	17-04-1974	0.1886	149.1	66.5	33.1	33.4	0.0
139	17-03-1974	26-03-1974	07-05-1974	0.1420	204.2	110.3	76.2	34.1	0.0
140	27-03-1974	28-03-1974	13-04-1974	0.3510	7.3	7.2	3.4	3.8	0.0
141	30-03-1974	02-04-1974	04-04-1974	100.0000	3.9	7.8	7.8	0.0	0.0
142	03-04-1974	08-04-1974	21-06-1974	0.0771	54.6	55.0	15.3	39.7	0.0
143	09-04-1974	14-04-1974	26-05-1974	0.1298	22.2	22.2	4.7	17.5	0.0
144	17-04-1974	22-04-1974	01-05-1974	0.5668	51.2	11.5	9.8	1.7	0.0
145	23-04-1974	28-04-1974	17-05-1974	0.3110	96.2	27.3	17.0	10.3	0.0
146	29-04-1974	03-05-1974	07-05-1974	100.0000	8.0	15.7	15.7	0.0	0.0
147	06-05-1974	07-05-1974	22-05-1974	0.3753	19.7	12.4	7.9	4.5	0.0
148	08-05-1974	10-05-1974	27-05-1974	0.3159	10.7	10.7	5.8	4.9	0.0
149	11-05-1974	14-05-1974	16-05-1974	100.0000	1.4	6.1	6.1	0.0	0.0
150	15-05-1974	17-05-1974	22-05-1974	100.0000	0.3	13.3	5.4	7.9	0.0
151	21-05-1974	22-05-1974	31-05-1974	100.0000	0.2	19.4	4.6	14.8	0.1
152	30-05-1974	31-05-1974	06-06-1974	100.0000	7.6	12.6	4.5	8.1	1.3
153	05-06-1974	05-06-1974	08-06-1974	100.0000	0.1	3.9	3.9	0.0	0.0
154	07-06-1974	08-06-1974	08-07-1974	0.1915	13.8	17.5	5.0	12.4	3.7
155	11-06-1974	15-06-1974	04-10-1974	0.0431	59.6	33.9	5.3	28.6	0.0
156	16-06-1974	20-06-1974	20-07-1974	0.1348	6.2	6.0	1.8	4.2	0.0
157	21-06-1974	23-06-1974	24-07-1974	0.1982	90.3	44.4	21.4	23.0	0.0
158	24-06-1974	27-06-1974	29-06-1974	100.0000	35.8	2.6	2.6	0.0	0.0
159	28-06-1974	29-06-1974	04-07-1974	1.0761	9.6	4.1	3.9	0.2	0.0
160	01-07-1974	10-07-1974	16-07-1974	100.0000	0.6	12.9	3.7	9.2	0.0
161	15-07-1974	21-07-1974	23-07-1974	100.0000	1.2	8.7	8.7	0.0	0.0
162	22-07-1974	27-07-1974	04-10-1974	0.0411	114.2	59.9	16.1	43.8	0.0
163	06-08-1974	10-08-1974	04-10-1974	0.0546	21.7	9.1	0.7	8.4	0.2
164	16-08-1974	19-08-1974	04-10-1974	0.0457	33.2	7.4	2.0	5.4	0.0
165	21-08-1974	25-08-1974	30-08-1974	100.0000	0.2	1.7	0.3	1.3	0.0
166	29-08-1974	05-09-1974	20-09-1974	0.3763	118.7	21.0	15.8	5.3	0.0
167	06-09-1974	07-09-1974	15-09-1974	0.7357	64.7	8.9	8.0	1.0	0.0
168	08-09-1974	10-09-1974	04-10-1974	0.1855	13.5	13.4	4.5	8.9	0.1
169	13-09-1974	17-09-1974	20-09-1974	100.0000	0.2	2.9	2.9	0.0	0.0
170	19-09-1974	25-09-1974	04-10-1974	0.4097	10.9	10.7	5.9	4.8	0.0
171	28-09-1974	01-10-1974	04-10-1974	0.0294	108.7	15.7	15.7	0.0	0.0
172	02-10-1974	05-10-1974	02-01-1975	100.0000	51.7	1.9	1.9	0.0	763.9
173	01-01-1975	02-01-1975	05-02-1975	0.1778	29.3	28.9	9.7	19.3	0.0
174	03-01-1975	16-01-1975	24-02-1975	0.0771	117.1	77.0	26.5	50.5	0.0
175	19-01-1975	24-01-1975	24-02-1975	0.0572	152.1	99.2	51.3	47.8	5.2
176	27-01-1975	31-01-1975	24-02-1975	0.1668	182.9	133.5	106.7	26.7	23.8
177	04-02-1975	07-02-1975	15-02-1975	0.8615	138.6	35.4	32.7	2.7	0.0
178	08-02-1975	11-02-1975	21-02-1975	100.0000	40.4	72.7	25.5	47.3	1.8
179	20-02-1975	21-02-1975	24-02-1975	0.4391	18.8	15.1	15.1	0.0	0.0
180	22-02-1975	24-02-1975	24-08-1975	0.0258	78.7	217.1	22.6	194.5	617.9
181	27-04-1975	27-04-1975	26-05-1975	0.1178	0.2	2.1	0.2	2.0	2.0
182	02-05-1975	05-05-1975	24-08-1975	0.0172	28.9	21.8	0.8	21.0	0.0
183	06-05-1975	09-05-1975	13-06-1975	0.0900	7.7	3.4	1.1	2.3	0.2
184	15-05-1975	21-05-1975	24-05-1975	1.3836	63.8	7.2	7.2	0.0	0.0
185	22-05-1975	27-05-1975	31-05-1975	100.0000	4.0	4.5	4.5	0.0	0.0
186	30-05-1975	31-05-1975	04-06-1975	100.0000	0.1	2.0	2.0	0.0	0.0
187	03-06-1975	04-06-1975	21-06-1975	0.2412	2.8	2.8	1.2	1.5	0.0
188	05-06-1975	06-06-1975	11-06-1975	1.1719	34.1	5.2	5.1	0.1	0.0
189	07-06-1975	08-06-1975	15-06-1975	100.0000	1.8	3.4	1.2	2.2	0.0
190	14-06-1975	15-06-1975	09-07-1975	0.1731	35.5	4.3	1.5	2.8	0.0
191	16-06-1975	16-06-1975	26-06-1975	1.0312	3.3	3.3	0.8	2.4	0.0
192	23-06-1975	26-06-1975	20-08-1975	0.0764	9.9	9.8	1.8	8.1	0.0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
193	27-06-1975	02-07-1975	17-07-1975	0.2717	23.5	6.2	4.3	1.9	6.9
194	06-07-1975	10-07-1975	24-08-1975	0.0631	7.3	6.9	0.8	6.1	0.0
195	12-07-1975	21-07-1975	24-08-1975	0.0979	115.4	60.1	50.9	9.2	0.0
196	25-07-1975	28-07-1975	24-08-1975	0.1266	27.1	9.7	2.2	7.5	0.1
197	05-08-1975	12-08-1975	24-08-1975	0.0801	9.9	6.9	1.6	5.2	0.0
198	14-08-1975	16-08-1975	24-08-1975	0.1456	19.1	2.5	0.7	1.8	0.0
199	18-08-1975	20-08-1975	02-10-1975	100.0000	44.3	2.7	1.5	1.2	263.1
200	01-10-1975	04-10-1975	18-10-1975	0.4016	53.8	15.2	10.4	4.7	0.0
201	05-10-1975	06-10-1975	22-11-1975	0.1045	28.1	14.5	3.1	11.4	0.0
202	07-10-1975	13-10-1975	02-11-1975	0.3110	98.2	34.3	21.2	13.1	0.0
203	15-10-1975	16-10-1975	02-11-1975	0.2651	9.5	4.1	2.0	2.1	0.0
204	17-10-1975	21-10-1975	20-01-1976	0.0638	45.3	54.3	7.1	47.1	8.6
205	31-10-1975	05-11-1975	30-12-1975	0.1016	106.9	40.6	14.7	25.9	11.0
206	10-11-1975	12-11-1975	25-12-1975	0.0900	16.2	6.3	1.5	4.8	0.0
207	13-11-1975	20-11-1975	06-02-1976	0.0698	84.2	40.8	6.9	33.9	0.0
208	21-11-1975	22-11-1975	28-11-1975	1.1395	36.4	5.4	4.8	0.6	16.1
209	25-11-1975	29-11-1975	26-12-1975	0.2291	169.5	55.3	38.8	16.5	0.0
210	30-11-1975	02-12-1975	12-04-1976	0.0441	123.5	107.9	33.3	74.6	0.1
211	07-12-1975	08-12-1975	10-12-1975	1.7780	22.8	0.6	0.6	0.0	0.0
212	09-12-1975	12-12-1975	20-01-1976	0.1083	19.2	7.8	2.0	5.8	0.0
213	13-12-1975	16-12-1975	26-02-1976	0.0817	192.4	117.0	72.1	45.0	56.6
214	23-12-1975	28-12-1975	23-01-1976	0.2551	322.5	184.4	158.7	25.7	0.0
215	29-12-1975	31-12-1975	12-01-1976	0.6990	78.2	35.5	13.8	21.7	18.2
216	04-01-1976	05-01-1976	30-01-1976	0.2409	22.0	22.0	9.7	12.2	0.0
217	06-01-1976	07-01-1976	13-01-1976	0.9219	40.6	9.5	9.0	0.5	0.0
218	08-01-1976	09-01-1976	08-02-1976	0.2180	46.0	27.3	5.4	21.9	5.1
219	13-01-1976	20-01-1976	22-01-1976	100.0000	6.5	18.5	18.5	0.0	0.0
220	21-01-1976	24-01-1976	25-03-1976	0.1076	280.7	240.3	176.6	63.6	18.2
221	27-01-1976	31-01-1976	07-02-1976	100.0000	446.7	546.2	534.6	11.6	7.0
222	06-02-1976	09-02-1976	13-02-1976	1.5723	150.8	19.2	19.1	0.1	0.0
223	10-02-1976	15-02-1976	17-02-1976	100.0000	9.2	10.4	10.4	0.0	0.0
224	16-02-1976	19-02-1976	23-03-1976	0.1574	19.0	18.8	9.2	9.6	0.0
225	20-02-1976	22-02-1976	14-03-1976	0.3042	46.2	29.1	17.3	11.8	0.0
226	23-02-1976	24-02-1976	12-03-1976	0.3691	56.6	20.2	12.8	7.5	0.0
227	25-02-1976	29-02-1976	15-03-1976	100.0000	100.1	176.3	30.1	146.2	3.1
228	14-03-1976	17-03-1976	18-04-1976	0.1997	99.1	49.8	26.6	23.2	0.0
229	18-03-1976	19-03-1976	24-03-1976	1.0595	23.7	6.8	6.6	0.2	0.0
230	20-03-1976	20-03-1976	22-04-1976	0.1747	19.3	18.8	4.8	14.0	0.0
231	22-03-1976	24-03-1976	29-07-1976	0.0442	73.7	70.1	9.8	60.3	0.0
232	25-03-1976	26-03-1976	17-04-1976	0.2750	58.7	20.5	10.4	10.1	0.0
233	27-03-1976	29-03-1976	22-04-1976	0.1900	26.6	7.9	3.7	4.2	0.0
234	30-03-1976	04-04-1976	10-04-1976	100.0000	138.9	191.8	171.1	20.7	0.9
235	09-04-1976	11-04-1976	01-05-1976	0.3019	22.6	22.6	12.8	9.7	0.0
236	12-04-1976	19-04-1976	08-07-1976	0.0831	383.7	325.0	220.4	104.5	0.0
237	22-04-1976	24-04-1976	17-05-1976	0.2397	80.1	24.6	16.1	8.4	3.5
238	27-04-1976	07-05-1976	09-06-1976	0.1794	35.6	35.6	12.7	22.9	0.0
239	09-05-1976	14-05-1976	19-08-1976	0.0565	54.9	51.2	8.4	42.8	0.0
240	15-05-1976	24-05-1976	12-07-1976	0.1110	61.3	35.5	12.3	23.2	0.0
241	25-05-1976	30-05-1976	29-12-1976	0.0265	110.7	115.7	7.9	107.7	0.3
242	04-06-1976	06-06-1976	25-06-1976	0.2420	51.3	6.5	3.8	2.7	0.0
243	09-06-1976	14-06-1976	15-07-1976	0.1598	18.4	13.0	4.7	8.3	0.0
244	17-06-1976	04-07-1976	05-09-1976	0.0925	176.5	80.0	37.4	42.7	1.2
245	08-07-1976	12-07-1976	19-09-1976	0.0839	133.0	57.5	20.7	36.8	0.3
246	19-07-1976	25-07-1976	28-07-1976	100.0000	0.1	4.4	4.4	0.0	0.0
247	27-07-1976	02-08-1976	05-08-1976	100.0000	1.7	8.7	8.7	0.0	0.0
248	04-08-1976	07-08-1976	21-10-1976	0.0684	30.2	29.8	6.1	23.8	0.0
249	09-08-1976	12-08-1976	06-09-1976	0.2158	51.9	13.8	5.8	8.0	0.0
250	13-08-1976	16-08-1976	21-09-1976	0.1332	95.6	16.9	8.3	8.6	0.0
251	19-08-1976	22-08-1976	05-06-1977	0.0176	135.5	115.1	21.3	93.8	0.1
252	29-08-1976	31-08-1976	06-09-1976	100.0000	45.4	1.4	1.4	0.0	0.0
253	05-09-1976	08-09-1976	16-10-1976	0.1233	74.6	14.1	5.7	8.4	0.3
254	11-09-1976	15-09-1976	26-09-1976	0.5166	68.7	14.2	11.8	2.4	0.0
255	16-09-1976	17-09-1976	27-01-1977	0.0365	21.5	35.8	3.3	32.4	21.2
256	22-09-1976	25-09-1976	02-03-1977	0.0222	32.7	16.3	1.6	14.7	0.0
257	27-09-1976	30-09-1976	10-10-1976	0.5094	64.2	13.1	11.7	1.4	0.0
258	01-10-1976	03-10-1976	12-10-1976	0.5757	66.9	5.7	4.7	1.0	0.0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
259	04-10-1976	08-10-1976	13-10-1976	0.9316	5.3	5.2	4.9	0.3	0.0
260	09-10-1976	11-10-1976	20-02-1977	0.0359	39.7	34.3	3.2	31.1	5.8
261	18-10-1976	20-10-1976	31-01-1977	0.0455	79.9	34.8	8.0	26.8	0.0
262	21-10-1976	22-10-1976	29-10-1976	100.0000	40.2	3.7	3.7	0.0	19.0
263	28-10-1976	29-10-1976	09-05-1977	0.0192	24.6	21.1	1.3	19.8	0.0
264	31-10-1976	02-11-1976	07-11-1976	0.7475	16.3	1.6	1.4	0.2	0.0
265	03-11-1976	09-11-1976	27-11-1976	0.2453	59.2	10.5	6.9	3.5	0.1
266	14-11-1976	14-11-1976	27-11-1976	0.3698	36.0	5.8	4.3	1.4	1.2
267	18-11-1976	22-11-1976	25-01-1977	0.0789	74.1	31.4	11.4	20.0	0.0
268	26-11-1976	28-11-1976	08-12-1976	0.5549	51.2	5.1	3.7	1.4	0.0
269	01-12-1976	03-12-1976	12-12-1976	1.0567	4.7	10.7	2.9	7.7	56.4
270	08-12-1976	10-12-1976	19-02-1977	0.0860	137.1	126.4	76.8	49.5	1.8
271	17-12-1976	18-12-1976	26-12-1976	0.7576	57.5	6.7	5.6	1.1	0.0
272	20-12-1976	27-12-1976	15-01-1977	0.2866	112.3	27.4	18.9	8.5	0.0
273	28-12-1976	29-12-1976	09-01-1977	0.5430	18.0	8.1	5.7	2.3	0.0
274	31-12-1976	08-01-1977	10-06-1977	0.0400	225.9	173.1	49.4	123.7	0.7
275	16-01-1977	21-01-1977	24-01-1977	1.6335	129.1	35.2	35.2	0.0	0.0
276	22-01-1977	28-01-1977	24-03-1977	0.1061	51.0	50.8	16.2	34.6	0.0
277	31-01-1977	02-02-1977	27-02-1977	0.2004	63.6	16.2	10.6	5.6	0.0
278	04-02-1977	15-02-1977	02-03-1977	100.0000	18.6	36.6	8.0	28.6	0.0
279	01-03-1977	04-03-1977	20-03-1977	0.3412	34.1	14.9	10.2	4.7	0.0
280	05-03-1977	07-03-1977	03-07-1977	0.0405	36.8	32.0	4.0	28.0	0.0
281	08-03-1977	13-03-1977	04-04-1977	0.2267	8.6	8.5	2.4	6.2	0.0
282	16-03-1977	19-03-1977	12-10-1977	0.0250	41.2	78.6	9.2	69.4	67.2
283	29-03-1977	30-03-1977	02-04-1977	1.2764	25.9	1.4	1.4	0.0	0.0
284	31-03-1977	04-04-1977	12-04-1977	0.7677	266.3	119.2	117.0	2.2	0.0
285	05-04-1977	06-04-1977	14-04-1977	0.6613	12.6	6.3	5.2	1.1	0.0
286	08-04-1977	12-04-1977	29-06-1977	0.0695	42.7	42.6	9.0	33.6	0.0
287	13-04-1977	14-04-1977	25-04-1977	0.1679	1.2	1.0	0.7	0.3	0.0
288	17-04-1977	22-04-1977	14-05-1977	0.2873	183.9	50.5	36.0	14.5	0.0
289	23-04-1977	26-04-1977	23-07-1977	0.0645	52.8	50.7	8.0	42.7	0.0
290	27-04-1977	28-04-1977	04-05-1977	0.4896	3.4	0.7	0.6	0.2	0.0
291	29-04-1977	03-05-1977	25-05-1977	0.2114	19.6	8.6	4.0	4.6	0.0
292	04-05-1977	14-05-1977	27-06-1977	0.1111	19.1	18.8	4.9	13.9	0.0
293	15-05-1977	20-05-1977	11-06-1977	0.2325	114.2	20.5	13.8	6.7	0.0
294	21-05-1977	04-06-1977	06-06-1977	100.0000	19.8	35.6	35.6	0.0	0.0
295	05-06-1977	07-06-1977	26-06-1977	0.2914	36.8	15.9	9.1	6.8	0.0
296	08-06-1977	09-06-1977	15-07-1977	0.1263	8.9	8.8	2.2	6.5	0.0
297	10-06-1977	19-06-1977	10-07-1977	0.2766	21.6	21.6	9.0	12.5	0.0
298	22-06-1977	24-06-1977	28-06-1977	1.2475	30.8	4.8	4.7	0.1	0.0
299	25-06-1977	28-06-1977	27-07-1977	0.1790	13.3	13.3	5.0	8.2	0.0
300	29-06-1977	07-07-1977	16-07-1977	100.0000	0.3	17.2	3.9	13.3	0.0
301	15-07-1977	20-07-1977	13-10-1977	0.0591	32.9	32.6	6.7	25.9	0.0
302	24-07-1977	26-07-1977	21-10-1977	0.0443	11.3	11.0	1.0	10.0	0.0
303	01-08-1977	04-08-1977	07-11-1977	0.0393	37.7	11.4	1.0	10.4	0.0
304	08-08-1977	11-08-1977	14-10-1977	0.0548	23.2	8.0	2.1	6.0	0.0
305	14-08-1977	18-08-1977	25-08-1977	0.5040	48.6	3.8	3.3	0.4	0.0
306	19-08-1977	20-08-1977	29-08-1977	0.5238	27.5	2.8	2.2	0.6	0.0
307	21-08-1977	21-08-1977	24-08-1977	100.0000	0.2	0.6	0.6	0.0	0.0
308	23-08-1977	27-08-1977	29-08-1977	6.5114	2.4	2.3	2.3	0.0	0.0
309	28-08-1977	31-08-1977	22-09-1977	0.2051	17.0	6.1	2.7	3.4	0.0
310	01-09-1977	05-09-1977	26-09-1977	0.2444	118.5	17.1	11.8	5.2	0.0
311	06-09-1977	08-09-1977	08-12-1977	0.0503	32.5	21.7	3.0	18.7	0.0
312	13-09-1977	22-09-1977	06-10-1977	0.3451	25.4	8.6	5.4	3.2	0.0
313	23-09-1977	26-09-1977	30-12-1977	0.0532	99.1	39.8	10.3	29.5	0.0
314	29-09-1977	01-10-1977	09-10-1977	0.6212	32.0	5.2	4.4	0.9	0.0
315	02-10-1977	03-10-1977	11-10-1977	0.7283	61.8	7.0	6.2	0.8	0.0
316	04-10-1977	09-10-1977	13-01-1978	0.0559	97.2	66.2	25.9	40.3	0.0
317	12-10-1977	15-10-1977	26-10-1977	0.3751	34.7	3.4	2.5	0.8	0.0
318	16-10-1977	21-10-1977	19-06-1978	0.0216	114.5	108.7	22.7	86.0	0.1
319	27-10-1977	30-10-1977	04-11-1977	1.1831	64.0	7.2	7.0	0.2	0.0
320	01-11-1977	02-11-1977	13-11-1977	0.4096	18.4	2.4	1.4	1.0	0.0
321	04-11-1977	05-11-1977	10-03-1978	0.0329	20.4	18.9	2.0	16.9	1.4
322	12-11-1977	14-11-1977	23-11-1977	0.5887	54.4	7.2	6.2	1.0	0.0
323	15-11-1977	19-11-1977	13-12-1977	0.2021	32.8	12.2	6.9	5.3	0.0
324	22-11-1977	28-11-1977	28-01-1978	0.0880	129.2	49.2	22.6	26.6	0.0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
325	29-11-1977	04-12-1977	16-06-1978	0.0244	53.7	52.7	6.2	46.5	0.0
326	05-12-1977	07-12-1977	09-12-1977	1.5271	18.7	0.9	0.8	0.0	0.0
327	08-12-1977	11-12-1977	02-01-1978	0.2566	128.8	22.3	14.1	8.3	0.0
328	12-12-1977	14-12-1977	06-05-1978	0.0308	28.5	27.8	1.8	25.9	0.0
329	16-12-1977	25-12-1977	27-04-1978	0.0449	155.3	84.8	24.6	60.1	0.0
330	01-01-1978	04-01-1978	17-01-1978	0.4719	183.4	31.0	25.8	5.2	0.0
331	07-01-1978	14-01-1978	15-02-1978	0.1894	153.7	153.6	127.7	25.9	0.0
332	15-01-1978	19-01-1978	27-06-1978	0.0380	240.9	227.5	113.4	114.1	32.0
333	22-01-1978	23-01-1978	05-02-1978	21.8548	4.6	1.1	0.2	1.0	0.0
334	04-02-1978	07-02-1978	02-04-1978	0.0964	155.2	22.9	5.1	17.8	0.0
335	08-02-1978	08-02-1978	12-02-1978	0.2588	1.6	0.5	0.4	0.1	0.0
336	10-02-1978	11-02-1978	14-02-1978	100.0000	1.0	0.1	0.1	0.0	0.0
337	13-02-1978	15-02-1978	29-06-1978	0.0243	29.1	10.7	0.5	10.2	0.0
338	16-02-1978	19-02-1978	26-02-1978	0.5007	32.7	2.8	2.5	0.4	0.0
339	20-02-1978	24-02-1978	11-03-1978	0.2885	44.3	8.1	6.0	2.1	0.0
340	25-02-1978	10-03-1978	28-08-1978	0.0367	495.4	358.1	190.1	168.0	0.3
341	28-03-1978	31-03-1978	09-07-1979	0.0100	36.2	119.5	15.1	104.4	100.1
342	08-04-1978	12-04-1978	26-05-1978	0.0882	44.3	7.9	3.3	4.7	1.1
343	19-04-1978	21-04-1978	04-06-1978	0.0785	22.1	4.3	1.1	3.2	19.4
344	28-04-1978	28-04-1978	01-05-1978	100.0000	0.1	0.2	0.2	0.0	0.0
345	30-04-1978	04-05-1978	27-05-1978	0.2210	87.6	22.4	16.6	5.8	0.0
346	08-05-1978	09-05-1978	23-05-1978	0.2206	1.1	1.1	0.4	0.6	0.0
347	10-05-1978	19-05-1978	08-06-1978	0.2768	99.3	23.4	14.7	8.6	0.0
348	21-05-1978	23-05-1978	04-06-1978	0.4166	34.6	5.5	3.9	1.6	0.0
349	24-05-1978	26-05-1978	29-05-1978	100.0000	0.3	2.4	2.4	0.0	0.0
350	28-05-1978	01-06-1978	13-06-1978	0.6359	9.2	9.1	3.1	6.0	0.0
351	06-06-1978	12-06-1978	18-08-1978	0.0852	67.9	43.2	14.0	29.2	0.0
352	21-06-1978	23-06-1978	25-06-1978	1.0832	17.0	0.5	0.5	0.0	0.0
353	24-06-1978	28-06-1978	04-07-1978	100.0000	0.6	1.6	0.3	1.3	0.0
354	03-07-1978	05-07-1978	07-07-1978	6.4075	1.2	1.1	1.1	0.0	0.0
355	06-07-1978	11-07-1978	13-07-1978	100.0000	1.0	2.9	2.9	0.0	0.0
356	12-07-1978	17-07-1978	07-09-1978	0.0767	22.0	10.1	2.9	7.2	0.0
357	18-07-1978	24-07-1978	01-08-1978	0.5706	55.8	3.9	3.2	0.7	0.0
358	25-07-1978	29-07-1978	13-08-1978	100.0000	2.2	7.3	1.4	5.9	0.0
359	12-08-1978	15-08-1978	20-09-1978	0.1315	84.7	16.5	8.9	7.6	0.8
360	21-08-1978	26-08-1978	22-10-1978	0.0812	81.0	21.9	9.7	12.2	0.0
361	31-08-1978	01-09-1978	02-04-1979	0.0207	51.7	42.0	2.1	39.9	0.0
362	02-09-1978	09-09-1978	14-09-1978	0.6983	54.1	7.7	7.6	0.1	0.0
363	13-09-1978	13-09-1978	27-09-1978	100.0000	0.3	1.3	0.0	1.2	0.2
364	26-09-1978	26-09-1978	03-10-1978	0.3416	0.4	0.3	0.2	0.1	0.0
365	28-09-1978	29-09-1978	01-10-1978	1.7317	0.3	0.0	0.0	0.0	0.0
366	30-09-1978	03-10-1978	07-10-1978	0.4694	1.1	0.3	0.2	0.1	0.0
367	04-10-1978	21-10-1978	25-10-1978	1.2444	110.1	10.7	10.5	0.2	0.0
368	23-10-1978	29-10-1978	11-11-1978	0.2780	28.1	3.0	1.9	1.1	0.0
369	30-10-1978	06-11-1978	19-12-1978	0.1197	198.4	30.9	16.1	14.8	0.5
370	11-11-1978	15-11-1978	07-02-1979	0.0584	127.0	40.7	16.9	23.8	2.3
371	22-11-1978	25-11-1978	01-12-1978	0.8935	107.2	9.0	8.5	0.4	0.0
372	27-11-1978	29-11-1978	17-01-1979	0.1080	76.2	25.4	8.8	16.6	0.0
373	04-12-1978	05-12-1978	21-03-1979	0.0297	8.9	7.8	0.4	7.3	0.0
374	07-12-1978	13-12-1978	05-01-1979	0.1889	66.6	8.9	4.6	4.3	0.0
375	14-12-1978	20-12-1978	11-02-1979	0.1321	113.3	57.9	9.2	48.6	93.8
376	30-12-1978	31-12-1978	14-01-1979	0.2953	56.1	3.0	1.6	1.4	0.0
377	01-01-1979	05-01-1979	22-02-1979	0.1188	128.4	52.9	27.7	25.2	0.0
378	08-01-1979	10-01-1979	20-01-1979	0.5077	19.4	5.4	4.0	1.4	0.0
379	12-01-1979	18-01-1979	21-02-1979	0.1562	18.7	18.5	5.5	13.0	0.0
380	19-01-1979	24-01-1979	15-04-1979	0.0636	76.2	38.1	10.1	28.0	0.0
381	26-01-1979	30-01-1979	13-02-1979	0.3860	88.6	14.9	10.6	4.3	0.0
382	01-02-1979	06-02-1979	13-07-1979	0.0343	48.0	69.8	5.8	64.0	22.2
383	14-02-1979	16-02-1979	25-02-1979	0.4075	23.1	1.5	1.1	0.4	0.0
384	17-02-1979	23-02-1979	06-03-1979	0.5816	39.7	11.0	7.2	3.8	0.0
385	27-02-1979	03-03-1979	01-06-1979	0.0606	202.4	78.9	39.4	39.6	0.0
386	11-03-1979	13-03-1979	15-03-1979	3.0672	113.2	51.3	51.3	0.0	0.0
387	14-03-1979	15-03-1979	21-03-1979	1.0055	28.5	11.5	11.0	0.5	0.0
388	16-03-1979	18-03-1979	01-05-1979	0.1223	24.4	21.6	6.6	15.0	0.0
389	19-03-1979	21-03-1979	13-05-1979	0.0948	27.7	22.6	8.4	14.2	0.0
390	23-03-1979	26-03-1979	11-05-1979	0.1250	76.3	32.9	9.9	23.0	0.0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
391	27-03-1979	27-03-1979	30-03-1979	46.8412	55.9	2.2	2.2	0.0	0.0
392	29-03-1979	05-04-1979	15-04-1979	0.5426	23.3	8.7	5.6	3.1	0.0
393	07-04-1979	08-04-1979	26-07-1979	0.0519	60.9	58.5	6.2	52.3	0.0
394	09-04-1979	11-04-1979	02-05-1979	0.2014	42.5	4.8	1.9	2.9	0.0
395	13-04-1979	14-04-1979	26-04-1979	0.6127	8.0	8.3	3.5	4.7	0.3
396	19-04-1979	26-04-1979	10-11-1979	0.0273	101.1	106.2	20.1	86.1	2.8
397	03-05-1979	08-05-1979	05-08-1979	0.0437	26.3	15.7	4.6	11.1	0.0
398	09-05-1979	13-05-1979	15-05-1979	1.4353	29.2	1.2	1.2	0.0	0.0
399	14-05-1979	17-05-1979	25-05-1979	1.2918	32.4	7.6	3.5	4.0	0.2
400	23-05-1979	25-05-1979	21-07-1979	0.0890	75.5	28.8	12.3	16.4	0.0
401	30-05-1979	01-06-1979	08-11-1979	0.0253	23.8	23.3	1.5	21.7	0.0
402	06-06-1979	11-06-1979	26-06-1979	0.2612	27.5	4.9	3.0	1.9	0.0
403	13-06-1979	16-06-1979	27-11-1979	0.0272	88.3	39.3	7.7	31.6	0.0
404	20-06-1979	20-06-1979	26-06-1979	100.0000	0.2	0.4	0.1	0.3	0.0
405	25-06-1979	29-06-1979	06-08-1979	0.1191	44.2	9.7	2.8	6.9	0.0
406	06-07-1979	07-07-1979	30-08-1979	0.0664	5.5	5.3	0.5	4.8	0.0
407	09-07-1979	12-07-1979	29-07-1979	0.3783	178.7	50.2	40.2	10.0	0.0
408	17-07-1979	17-07-1979	10-09-1979	0.0817	11.2	11.0	1.4	9.6	0.0
409	19-07-1979	20-07-1979	07-09-1979	0.0830	7.4	7.3	0.9	6.3	0.0
410	23-07-1979	27-07-1979	11-11-1979	0.0392	30.9	20.5	2.6	17.8	0.0
411	08-08-1979	10-08-1979	17-08-1979	0.5131	2.0	0.7	0.5	0.2	0.0
412	12-08-1979	14-08-1979	28-08-1979	0.3205	29.9	3.7	2.0	1.7	0.0
413	15-08-1979	17-08-1979	25-08-1979	0.4865	30.5	4.1	3.6	0.5	0.0
414	18-08-1979	22-08-1979	03-01-1980	0.0382	149.2	66.1	22.1	44.0	1.1
415	27-08-1979	28-08-1979	13-09-1979	0.1880	17.4	1.4	0.7	0.8	0.6
416	31-08-1979	03-09-1979	28-10-1979	0.1141	86.7	66.7	18.4	48.2	0.0
417	04-09-1979	06-09-1979	10-09-1979	44.6282	159.3	20.8	20.8	0.0	0.0
418	09-09-1979	10-09-1979	12-09-1979	43.9046	8.9	0.1	0.1	0.0	0.0
419	11-09-1979	12-09-1979	28-09-1979	0.3815	49.2	15.0	8.1	6.9	0.0
420	14-09-1979	15-09-1979	28-09-1979	0.3299	22.1	3.5	2.0	1.4	0.0
421	16-09-1979	21-09-1979	17-11-1979	0.1076	160.9	71.6	30.0	41.6	0.0
422	23-09-1979	23-09-1979	26-09-1979	1.8151	15.1	1.1	1.1	0.0	0.0
423	25-09-1979	06-10-1979	13-10-1979	0.8400	17.0	15.2	12.9	2.4	0.0
424	08-10-1979	16-10-1979	21-03-1980	0.0352	190.6	175.6	98.9	76.7	0.4
425	25-10-1979	25-10-1979	28-10-1979	100.0000	0.1	0.2	0.2	0.0	0.0
426	27-10-1979	28-10-1979	05-11-1979	0.5064	11.7	2.1	1.6	0.5	0.0
427	29-10-1979	30-10-1979	27-01-1980	0.0434	11.6	11.3	1.0	10.3	0.0
428	31-10-1979	01-11-1979	06-11-1979	0.8193	21.7	1.6	1.5	0.1	0.0
429	02-11-1979	05-11-1979	08-12-1979	0.1301	52.4	9.8	4.5	5.2	3.6
430	09-11-1979	12-11-1979	22-12-1979	0.1661	404.1	162.0	120.8	41.2	0.0
431	15-11-1979	20-11-1979	30-11-1979	0.6595	39.6	14.4	11.2	3.3	0.0
432	23-11-1979	27-11-1979	15-01-1980	0.1345	160.0	70.6	22.9	47.7	6.0
433	04-12-1979	05-12-1979	04-01-1980	0.2723	61.9	33.5	3.3	30.2	30.2
434	15-12-1979	21-12-1979	30-03-1980	0.0611	202.9	194.9	116.9	78.0	0.0
435	22-12-1979	26-12-1979	09-01-1980	0.3870	75.4	20.6	16.1	4.5	0.0
436	27-12-1979	28-12-1979	24-01-1980	0.2114	14.6	14.6	3.8	10.8	0.0
437	01-01-1980	03-01-1980	10-05-1980	0.0418	82.8	54.2	5.5	48.7	0.0
438	05-01-1980	11-01-1980	24-02-1980	0.1202	60.5	20.5	3.9	16.5	0.0
439	12-01-1980	15-01-1980	02-04-1980	0.0768	136.2	93.3	43.9	49.4	1.0
440	18-01-1980	19-01-1980	23-01-1980	1.3494	27.6	4.8	4.7	0.1	0.0
441	21-01-1980	29-01-1980	02-03-1980	0.1725	74.7	36.7	16.4	20.3	0.0
442	01-02-1980	05-02-1980	13-04-1980	0.1004	282.0	226.6	140.6	86.0	0.0
443	13-02-1980	15-02-1980	06-03-1980	0.2524	18.5	7.9	4.0	3.9	0.0
444	16-02-1980	19-02-1980	20-03-1980	0.1744	16.7	14.5	5.6	8.9	0.0
445	20-02-1980	21-02-1980	03-04-1980	0.1723	263.7	90.8	30.9	59.9	35.8
446	29-02-1980	10-03-1980	10-05-1980	0.0985	57.5	57.2	9.1	48.1	0.0
447	13-03-1980	17-03-1980	29-07-1980	0.0423	70.8	70.3	7.9	62.4	0.0
448	30-03-1980	01-04-1980	14-04-1980	0.4876	216.4	51.0	45.3	5.7	6.5
449	05-04-1980	08-04-1980	23-06-1980	0.0745	79.3	45.3	9.0	36.4	6.8
450	13-04-1980	17-04-1980	14-01-1981	0.0187	116.0	105.1	17.4	87.7	0.4
451	29-04-1980	30-04-1980	03-05-1980	100.0000	0.2	0.4	0.4	0.0	0.0
452	02-05-1980	05-05-1980	20-06-1980	0.0839	13.0	7.9	2.4	5.5	0.0
453	12-05-1980	13-05-1980	08-08-1980	0.0532	17.4	17.1	0.5	16.5	0.0
454	22-05-1980	24-05-1980	31-05-1980	0.5413	8.4	1.2	1.0	0.3	0.0
455	25-05-1980	26-05-1980	03-06-1980	100.0000	0.9	1.8	0.4	1.4	0.0
456	02-06-1980	04-06-1980	19-07-1980	0.1148	13.1	9.8	1.5	8.3	3.6

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
457	17-06-1980	19-06-1980	22-06-1980	100.0000	0.1	0.4	0.4	0.0	0.0
458	21-06-1980	24-06-1980	22-07-1980	0.1597	128.1	13.7	8.9	4.8	0.0
459	26-06-1980	27-06-1980	21-07-1980	0.1651	34.6	4.9	2.4	2.5	0.0
460	30-06-1980	06-07-1980	19-08-1980	0.1201	104.3	42.1	25.1	17.0	0.0
461	10-07-1980	12-07-1980	15-08-1980	0.1108	6.2	4.4	1.0	3.4	0.0
462	15-07-1980	16-07-1980	27-07-1980	0.4155	40.4	2.8	1.9	0.9	0.0
463	18-07-1980	23-07-1980	13-09-1980	0.0885	10.2	12.4	1.5	10.9	2.5
464	30-07-1980	02-08-1980	17-11-1980	0.0442	127.5	37.1	12.3	24.8	0.0
465	09-08-1980	11-08-1980	04-10-1980	0.0622	16.3	5.1	1.0	4.2	0.0
466	12-08-1980	15-08-1980	20-08-1980	0.8171	38.3	4.7	4.5	0.1	0.0
467	16-08-1980	21-08-1980	08-09-1980	0.2234	14.3	4.4	2.1	2.2	0.0
468	23-08-1980	25-08-1980	10-10-1980	0.0968	31.9	10.5	2.3	8.1	0.0
469	26-08-1980	28-08-1980	24-01-1981	0.0305	101.3	42.6	11.4	31.2	1.1
470	09-09-1980	12-09-1980	18-10-1980	0.1302	68.9	15.6	7.5	8.1	1.0
471	15-09-1980	19-09-1980	04-11-1980	0.1026	52.1	18.4	8.2	10.2	0.0
472	21-09-1980	26-09-1980	18-11-1980	0.0879	80.7	39.0	26.3	12.7	0.0
473	27-09-1980	27-09-1980	07-10-1980	0.2244	1.0	0.4	0.1	0.3	0.0
474	29-09-1980	07-10-1980	29-01-1981	0.0471	93.1	53.4	8.2	45.2	0.0
475	08-10-1980	10-10-1980	12-10-1980	100.0000	46.6	6.2	6.2	0.0	0.0
476	11-10-1980	15-10-1980	28-05-1981	0.0231	113.4	107.1	26.6	80.5	1.1
477	23-10-1980	26-10-1980	10-11-1980	0.3162	86.7	8.4	5.7	2.7	0.0
478	27-10-1980	28-10-1980	12-11-1980	0.3081	23.4	10.3	8.6	1.7	0.0
479	31-10-1980	01-11-1980	07-12-1980	0.1492	74.8	21.4	9.1	12.4	0.3
480	08-11-1980	13-11-1980	17-01-1981	0.0758	86.6	29.7	11.6	18.2	0.0
481	18-11-1980	26-11-1980	30-01-1981	0.0853	158.5	40.1	11.4	28.6	1.5
482	30-11-1980	04-12-1980	22-01-1981	0.0906	42.6	13.5	4.5	9.0	0.0
483	05-12-1980	09-12-1980	29-12-1980	0.2528	65.7	14.2	8.7	5.5	0.0
484	11-12-1980	14-12-1980	18-01-1981	0.1634	46.8	23.9	8.5	15.4	0.0
485	15-12-1980	15-12-1980	18-12-1980	46.1800	17.8	1.1	1.1	0.0	0.0
486	17-12-1980	24-12-1980	13-01-1981	0.3141	89.8	39.1	25.1	14.0	0.0
487	25-12-1980	31-12-1980	22-04-1981	0.0563	111.4	129.9	32.9	97.0	18.3
488	08-01-1981	13-01-1981	24-02-1981	0.1376	77.1	33.1	8.4	24.7	0.0
489	14-01-1981	18-01-1981	10-05-1981	0.0497	156.1	92.0	38.1	53.9	0.0
490	19-01-1981	20-01-1981	01-02-1981	0.3442	6.1	2.7	1.6	1.1	0.0
491	21-01-1981	23-01-1981	13-03-1981	0.1172	60.4	31.1	9.3	21.9	3.3
492	29-01-1981	04-02-1981	21-03-1981	0.1210	23.9	23.9	5.0	18.9	0.0
493	05-02-1981	08-02-1981	13-03-1981	0.1610	71.1	23.5	13.0	10.5	0.0
494	10-02-1981	13-02-1981	06-08-1981	0.0336	93.5	93.5	4.0	89.4	0.2
495	03-03-1981	06-03-1981	29-03-1981	0.2001	46.1	7.6	3.6	4.0	0.0
496	09-03-1981	10-03-1981	18-03-1981	0.6172	23.7	6.8	6.1	0.7	0.0
497	12-03-1981	22-03-1981	04-09-1981	0.0335	229.3	120.0	37.9	82.1	0.2
498	26-03-1981	26-03-1981	30-03-1981	1.7029	11.4	2.3	2.3	0.0	0.0
499	28-03-1981	29-03-1981	23-04-1981	0.2079	21.8	11.0	4.4	6.6	0.0
500	30-03-1981	30-03-1981	02-04-1981	1.7083	19.4	1.7	1.7	0.0	0.0
501	01-04-1981	02-04-1981	08-04-1981	1.0251	7.2	5.6	5.3	0.3	0.0
502	04-04-1981	07-04-1981	17-04-1981	100.0000	21.3	27.1	11.4	15.7	2.5
503	16-04-1981	20-04-1981	30-08-1981	0.0457	241.1	223.7	118.3	105.4	16.5
504	27-04-1981	28-04-1981	01-05-1981	3.2776	11.7	1.8	1.8	0.0	0.0
505	30-04-1981	30-04-1981	07-05-1981	0.4507	6.5	0.6	0.4	0.2	0.0
506	02-05-1981	04-05-1981	16-05-1981	100.0000	81.2	27.9	22.7	5.3	0.0
507	15-05-1981	18-05-1981	30-05-1981	0.5000	35.8	12.3	7.9	4.4	0.0
508	21-05-1981	22-05-1981	12-08-1981	0.0632	59.4	30.1	4.8	25.3	7.2
509	30-05-1981	05-06-1981	11-06-1981	0.8595	23.5	7.2	6.6	0.6	0.0
510	06-06-1981	08-06-1981	30-07-1981	0.1041	21.6	21.3	3.7	17.6	0.4
511	15-06-1981	16-06-1981	03-07-1981	0.1576	2.6	1.0	0.3	0.7	0.0
512	17-06-1981	24-06-1981	04-07-1981	100.0000	3.1	9.2	1.3	7.9	0.0
513	03-07-1981	08-07-1981	27-08-1981	0.1122	132.7	38.1	17.1	21.0	0.0
514	17-07-1981	21-07-1981	29-07-1981	0.6008	46.5	5.3	4.6	0.7	0.0
515	22-07-1981	26-07-1981	29-09-1981	0.0844	26.9	26.7	4.0	22.7	0.0
516	07-08-1981	13-08-1981	24-02-1982	0.0247	83.9	58.8	8.4	50.4	0.0
517	14-08-1981	15-08-1981	29-08-1981	0.2156	11.6	1.1	0.5	0.6	0.0
518	18-08-1981	20-08-1981	29-08-1981	0.3650	17.1	1.5	1.0	0.4	0.0
519	21-08-1981	21-08-1981	29-09-1981	0.0878	5.5	2.8	0.5	2.3	1.2
520	31-08-1981	03-09-1981	23-09-1981	0.2278	108.3	9.9	6.6	3.2	0.0
521	04-09-1981	05-09-1981	11-09-1981	0.4363	2.5	0.5	0.4	0.2	0.0
522	06-09-1981	08-09-1981	15-09-1981	100.0000	0.8	1.8	0.3	1.5	0.0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
523	14-09-1981	14-09-1981	17-09-1981	100.0000	0.3	0.6	0.6	0.0	0.0
524	16-09-1981	17-09-1981	23-09-1981	100.0000	0.7	6.5	1.6	4.9	0.0
525	22-09-1981	23-09-1981	03-10-1981	0.5236	56.8	5.5	4.2	1.2	0.0
526	24-09-1981	26-09-1981	09-10-1981	0.3406	23.2	4.1	2.6	1.5	0.0
527	27-09-1981	29-09-1981	11-10-1981	0.2953	10.1	3.3	2.5	0.8	0.0
528	30-09-1981	02-10-1981	20-12-1981	0.0613	93.1	29.9	10.8	19.1	0.2
529	06-10-1981	10-10-1981	30-11-1981	0.1089	114.2	31.8	8.8	23.0	0.0
530	11-10-1981	12-10-1981	14-10-1981	45.6727	3.1	0.7	0.7	0.0	0.0
531	13-10-1981	14-10-1981	17-10-1981	6.5776	4.9	4.6	4.6	0.0	0.0
532	16-10-1981	16-10-1981	19-10-1981	100.0000	3.0	4.8	4.8	0.0	0.0
533	18-10-1981	21-10-1981	03-01-1982	0.0725	50.9	39.6	11.4	28.3	0.0
534	26-10-1981	29-10-1981	17-11-1981	0.2221	39.6	6.5	3.9	2.6	0.0
535	30-10-1981	31-10-1981	14-02-1982	0.0402	22.8	19.1	2.2	16.9	0.0
536	03-11-1981	06-11-1981	29-11-1981	0.1569	28.7	3.0	1.0	2.0	0.0
537	07-11-1981	12-11-1981	19-11-1981	1.0654	126.6	47.2	45.7	1.5	0.0
538	13-11-1981	16-11-1981	18-12-1981	0.1870	37.4	36.8	16.9	19.9	0.0
539	17-11-1981	22-11-1981	16-03-1982	0.0426	37.7	35.7	4.2	31.5	0.0
540	23-11-1981	27-11-1981	29-01-1982	0.0754	23.3	18.1	3.1	15.0	0.3
541	30-11-1981	05-12-1981	03-02-1982	0.0836	103.5	25.1	6.4	18.7	0.0
542	07-12-1981	12-12-1981	28-01-1982	0.1261	189.5	112.7	82.2	30.6	1.4
543	16-12-1981	18-12-1981	22-01-1982	0.1861	92.9	47.7	25.3	22.4	18.4
544	24-12-1981	30-12-1981	19-02-1982	0.0974	39.4	20.4	4.6	15.7	0.0
545	01-01-1982	04-01-1982	09-01-1982	1.5547	179.3	34.7	34.5	0.2	0.0
546	05-01-1982	05-01-1982	16-01-1982	0.6601	15.1	15.1	8.6	6.5	0.2
547	08-01-1982	14-01-1982	28-03-1982	0.0883	93.7	88.6	19.6	69.0	0.5
548	22-01-1982	25-01-1982	21-04-1982	0.0650	131.3	72.8	32.6	40.2	0.0
549	29-01-1982	08-02-1982	24-09-1982	0.0245	146.5	134.2	21.3	112.9	1.1
550	22-02-1982	26-02-1982	07-03-1982	0.7075	122.9	19.9	17.8	2.1	0.0
551	27-02-1982	02-03-1982	25-03-1982	0.2722	86.9	44.7	29.4	15.2	0.0
552	03-03-1982	05-03-1982	12-03-1982	0.7865	64.0	12.1	11.4	0.7	0.0
553	06-03-1982	10-03-1982	24-03-1982	0.4432	21.3	21.2	15.3	5.9	0.0
554	11-03-1982	16-03-1982	21-05-1982	0.0846	43.0	43.0	11.2	31.8	0.0
555	17-03-1982	22-03-1982	03-04-1982	0.4111	6.8	6.8	4.7	2.1	0.0
556	23-03-1982	31-03-1982	28-05-1982	0.1006	65.4	64.8	26.6	38.2	0.0
557	01-04-1982	02-04-1982	05-04-1982	1.8694	21.6	7.7	7.7	0.0	0.0
558	04-04-1982	10-04-1982	27-07-1982	0.0497	121.9	57.4	11.3	46.1	0.0
559	12-04-1982	14-04-1982	25-04-1982	0.3908	2.4	2.4	1.4	0.9	0.0
560	15-04-1982	19-04-1982	21-06-1982	0.0725	76.1	19.0	5.5	13.4	0.0
561	21-04-1982	30-04-1982	17-05-1982	0.3462	29.9	18.3	7.0	11.3	0.2
562	04-05-1982	05-05-1982	27-07-1982	0.0682	33.8	33.7	2.2	31.5	0.0
563	19-05-1982	21-05-1982	27-05-1982	0.6521	24.6	1.7	1.5	0.2	0.0
564	22-05-1982	29-05-1982	06-06-1982	0.6464	52.3	8.8	7.8	1.0	0.0
565	30-05-1982	05-06-1982	07-06-1982	100.0000	1.1	6.0	6.0	0.0	0.0
566	06-06-1982	07-06-1982	11-09-1982	0.0503	18.5	26.4	2.9	23.5	15.6
567	13-06-1982	14-06-1982	20-06-1982	1.3901	27.3	6.6	6.0	0.7	13.6
568	17-06-1982	18-06-1982	18-07-1982	0.1553	5.9	7.0	1.8	5.2	1.2
569	22-06-1982	24-06-1982	27-06-1982	1.5166	24.9	6.7	6.7	0.0	0.0
570	25-06-1982	27-06-1982	01-07-1982	2.1354	90.0	21.8	21.7	0.1	0.0
571	29-06-1982	30-06-1982	11-08-1982	0.1174	13.8	12.5	3.0	9.5	0.0
572	01-07-1982	03-07-1982	05-08-1982	0.1091	6.9	4.0	1.0	3.0	0.0
573	06-07-1982	12-07-1982	28-12-1982	0.0247	28.1	28.5	2.0	26.5	0.0
574	14-07-1982	17-07-1982	12-08-1982	0.1188	2.2	2.1	0.5	1.6	0.0
575	19-07-1982	21-07-1982	14-09-1982	0.0719	36.2	10.7	4.1	6.6	0.0
576	28-07-1982	02-08-1982	15-10-1982	0.0565	91.3	21.0	9.3	11.7	0.0
577	03-08-1982	05-08-1982	07-10-1982	0.0613	32.7	12.2	5.1	7.1	6.6
578	09-08-1982	13-08-1982	06-12-1982	0.0423	122.1	60.6	30.0	30.7	0.6
579	18-08-1982	20-08-1982	11-12-1982	0.0366	55.1	18.4	1.8	16.5	0.9
580	24-08-1982	24-08-1982	02-09-1982	0.3877	13.8	1.1	0.8	0.3	1.3
581	31-08-1982	03-09-1982	27-10-1982	0.0692	35.7	9.9	4.0	5.9	0.0
582	06-09-1982	08-09-1982	13-01-1983	0.0409	256.7	105.4	63.0	42.4	0.7
583	15-09-1982	17-09-1982	20-09-1982	100.0000	0.3	0.5	0.5	0.0	0.0
584	19-09-1982	23-09-1982	17-11-1982	0.0737	32.8	9.2	1.5	7.7	0.0
585	28-09-1982	30-09-1982	19-01-1983	0.0428	69.3	28.0	1.7	26.4	32.8
586	08-10-1982	12-10-1982	07-11-1982	0.2194	135.3	31.0	18.8	12.1	0.0
587	13-10-1982	14-10-1982	17-10-1982	1.3920	23.8	1.6	1.6	0.0	0.0
588	15-10-1982	19-10-1982	26-11-1982	0.1183	9.4	9.3	2.4	6.9	0.0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
589	20-10-1982	28-10-1982	03-11-1982	0.7590	72.1	10.3	9.8	0.5	0.0
590	29-10-1982	30-10-1982	04-12-1982	0.1593	31.2	18.0	5.5	12.5	0.0
591	03-11-1982	03-11-1982	06-11-1982	6.3851	0.8	0.7	0.7	0.0	0.0
592	05-11-1982	11-11-1982	02-12-1982	0.2430	47.2	14.1	7.4	6.6	0.0
593	12-11-1982	16-11-1982	03-01-1983	0.1280	114.0	68.7	35.0	33.8	0.0
594	17-11-1982	18-11-1982	25-11-1982	0.5877	32.5	2.1	1.7	0.4	0.0
595	19-11-1982	20-11-1982	26-12-1982	0.1275	10.1	8.2	2.1	6.1	0.0
596	21-11-1982	23-11-1982	07-12-1982	0.3613	22.8	7.2	4.8	2.4	0.0
597	24-11-1982	25-11-1982	22-01-1983	0.0758	20.0	11.2	1.7	9.5	0.0
598	26-11-1982	29-11-1982	15-12-1982	0.2666	6.1	4.0	1.7	2.3	0.0
599	01-12-1982	06-12-1982	18-02-1983	0.0830	223.3	101.0	45.9	55.1	0.0
600	07-12-1982	10-12-1982	18-02-1983	0.0649	45.6	17.8	3.6	14.2	0.0
601	11-12-1982	13-12-1982	23-12-1982	0.4572	20.9	3.7	2.9	0.8	0.0
602	14-12-1982	23-12-1982	05-04-1983	0.0514	62.6	53.6	10.8	42.8	0.0
603	24-12-1982	31-12-1982	22-01-1983	0.2980	49.8	28.8	7.2	21.6	9.6
604	05-01-1983	08-01-1983	04-04-1983	0.0521	27.2	18.8	2.5	16.3	0.0
605	09-01-1983	14-01-1983	16-04-1983	0.0623	82.7	70.0	24.0	46.0	5.4
606	18-01-1983	22-01-1983	22-02-1983	0.2076	62.1	25.4	8.4	17.0	13.2
607	29-01-1983	07-02-1983	04-05-1983	0.0731	346.6	295.6	212.3	83.3	0.0
608	08-02-1983	10-02-1983	24-02-1983	0.3350	57.2	6.8	5.0	1.8	0.0
609	11-02-1983	15-02-1983	14-04-1983	0.1024	111.9	66.9	29.9	37.0	11.2
610	19-02-1983	22-02-1983	25-02-1983	100.0000	0.6	3.7	3.7	0.0	0.0
611	24-02-1983	28-02-1983	05-03-1983	1.1753	27.6	14.4	14.1	0.3	0.0
612	01-03-1983	04-03-1983	11-05-1983	0.0810	52.4	37.5	8.0	29.5	0.0
613	05-03-1983	08-03-1983	24-07-1983	0.0395	102.7	77.5	18.8	58.7	16.8
614	14-03-1983	16-03-1983	06-04-1983	0.2278	54.2	10.6	6.3	4.4	0.0
615	19-03-1983	21-03-1983	07-04-1983	0.3819	140.8	44.8	35.2	9.7	0.0
616	22-03-1983	28-03-1983	14-06-1983	0.0740	67.0	66.2	20.0	46.2	0.0
617	30-03-1983	31-03-1983	24-04-1983	0.2123	9.2	7.4	2.4	5.0	0.0
618	03-04-1983	08-04-1983	03-11-1983	0.0275	154.9	156.4	40.2	116.2	1.6
619	16-04-1983	20-04-1983	31-05-1983	0.1330	64.6	28.9	12.4	16.5	0.0
620	21-04-1983	22-04-1983	28-04-1983	0.9257	67.0	5.0	4.7	0.3	0.0
621	23-04-1983	23-04-1983	20-05-1983	0.2086	13.6	13.2	3.9	9.3	17.4
622	26-04-1983	29-04-1983	24-06-1983	0.0877	26.7	17.7	3.1	14.6	0.0
623	01-05-1983	05-05-1983	30-07-1983	0.0617	48.5	49.1	16.9	32.2	0.7
624	08-05-1983	09-05-1983	19-05-1983	0.4151	1.2	1.2	0.6	0.6	0.0
625	12-05-1983	15-05-1983	13-06-1983	0.1749	56.4	16.7	9.3	7.4	0.0
626	17-05-1983	22-05-1983	31-05-1983	0.5535	30.4	11.0	9.7	1.3	0.0
627	23-05-1983	26-05-1983	24-07-1983	0.0976	61.6	37.7	8.3	29.4	0.0
628	27-05-1983	29-05-1983	06-06-1983	0.6882	39.9	8.9	7.9	1.0	0.0
629	30-05-1983	07-06-1983	29-06-1983	0.3043	197.9	66.0	37.9	28.1	0.0
630	08-06-1983	10-06-1983	15-06-1983	1.4851	34.4	23.9	23.7	0.2	0.0
631	11-06-1983	12-06-1983	19-06-1983	0.9024	52.5	20.7	19.5	1.2	0.0
632	13-06-1983	17-06-1983	25-06-1983	100.0000	3.3	44.1	15.6	28.6	0.0
633	24-06-1983	28-06-1983	22-07-1983	0.2496	29.6	29.6	17.0	12.5	0.0
634	29-06-1983	01-07-1983	11-07-1983	0.5344	7.7	7.6	6.1	1.6	0.0
635	02-07-1983	08-07-1983	14-07-1983	100.0000	3.8	21.6	5.3	16.3	0.0
636	13-07-1983	14-07-1983	18-07-1983	100.0000	4.4	9.0	9.0	0.0	0.0
637	17-07-1983	19-07-1983	30-07-1983	0.5280	53.7	14.5	11.6	2.9	0.0
638	20-07-1983	22-07-1983	26-10-1983	0.0581	48.9	52.8	8.4	44.4	3.9
639	27-07-1983	29-07-1983	12-08-1983	0.2588	2.9	1.7	0.7	1.0	0.0
640	31-07-1983	06-08-1983	27-10-1983	0.0612	80.7	43.3	18.0	25.3	0.0
641	10-08-1983	17-08-1983	08-09-1983	0.2210	17.6	9.0	3.7	5.2	0.0
642	18-08-1983	19-08-1983	27-08-1983	0.6621	27.0	4.5	3.9	0.6	0.0
643	20-08-1983	21-08-1983	27-08-1983	0.7147	39.3	1.8	1.6	0.2	0.0
644	22-08-1983	28-08-1983	03-09-1983	100.0000	0.8	7.9	2.7	5.2	0.0
645	02-09-1983	06-09-1983	04-10-1983	0.1878	80.6	17.9	8.9	9.0	0.0
646	07-09-1983	10-09-1983	23-09-1983	0.4486	81.9	34.7	30.4	4.2	0.0
647	11-09-1983	14-09-1983	01-11-1983	0.1288	70.2	45.7	11.4	34.3	22.1
648	18-09-1983	21-09-1983	28-09-1983	0.7872	95.6	16.1	15.1	1.0	0.0
649	22-09-1983	27-09-1983	06-01-1984	0.0573	80.1	79.8	21.4	58.4	0.0
650	30-09-1983	07-10-1983	14-12-1983	0.0706	78.7	26.6	8.1	18.5	0.0
651	08-10-1983	12-10-1983	14-11-1983	0.1491	28.8	13.7	5.0	8.7	0.0
652	13-10-1983	15-10-1983	05-02-1984	0.0413	27.7	27.8	2.7	25.1	0.0
653	18-10-1983	20-10-1983	26-10-1983	0.9999	151.9	27.5	26.9	0.6	0.0
654	21-10-1983	26-10-1983	15-02-1984	0.0540	200.8	117.5	35.3	82.2	0.1

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
655	31-10-1983	02-11-1983	08-11-1983	0.8525	26.9	3.6	3.4	0.2	0.0
656	03-11-1983	05-11-1983	08-12-1983	0.1387	7.6	7.2	1.2	6.0	0.0
657	10-11-1983	12-11-1983	18-12-1983	0.1160	6.2	5.9	1.2	4.8	0.0
658	15-11-1983	16-11-1983	19-11-1983	6.4437	0.8	0.7	0.7	0.0	0.0
659	18-11-1983	21-11-1983	03-12-1983	0.3593	14.3	3.8	2.4	1.4	0.0
660	22-11-1983	23-11-1983	05-08-1984	0.0183	58.5	60.2	3.6	56.6	0.0
661	02-12-1983	06-12-1983	15-12-1983	0.5224	36.4	2.9	1.9	1.0	0.0
662	09-12-1983	12-12-1983	20-12-1983	0.6129	20.3	3.8	2.9	0.8	0.0
663	14-12-1983	19-12-1983	02-01-1984	0.2991	17.6	6.1	4.4	1.7	0.0
664	20-12-1983	24-12-1983	13-01-1984	0.2527	48.3	10.0	5.0	5.0	0.0
665	25-12-1983	28-12-1983	17-01-1984	0.2442	43.6	13.4	9.0	4.5	0.0
666	29-12-1983	30-12-1983	15-01-1984	0.2396	25.5	2.6	1.2	1.4	0.0
667	31-12-1983	01-01-1984	09-01-1984	0.6134	18.2	2.5	1.9	0.6	0.0
668	03-01-1984	07-01-1984	08-06-1984	0.0283	38.5	28.7	2.1	26.6	0.0
669	10-01-1984	10-01-1984	18-01-1984	0.8465	12.3	0.9	0.9	0.1	0.0
670	17-01-1984	17-01-1984	20-01-1984	0.8269	0.9	0.1	0.1	0.0	0.0
671	19-01-1984	22-01-1984	30-01-1984	0.9318	130.7	36.3	34.1	2.2	0.0
672	23-01-1984	24-01-1984	28-01-1984	1.7596	120.3	15.8	15.8	0.0	0.0
673	25-01-1984	28-01-1984	03-02-1984	0.9280	76.6	21.9	21.2	0.7	0.0
674	29-01-1984	02-02-1984	30-03-1984	0.0931	68.1	32.3	10.9	21.4	0.0
675	05-02-1984	09-02-1984	10-07-1984	0.0364	176.9	122.6	55.1	67.5	0.0
676	24-02-1984	25-02-1984	07-04-1984	0.1168	8.9	5.9	0.2	5.7	2.0
677	08-03-1984	09-03-1984	27-05-1984	0.0476	26.0	10.5	2.2	8.4	0.8
678	14-03-1984	14-03-1984	12-04-1984	0.0971	5.0	1.8	0.5	1.3	1.6
679	17-03-1984	17-03-1984	20-03-1984	100.0000	0.1	0.1	0.1	0.0	0.0
680	19-03-1984	23-03-1984	16-05-1984	0.0788	58.0	12.6	3.9	8.7	0.0
681	29-03-1984	01-04-1984	19-04-1984	0.3160	237.7	56.5	51.1	5.4	0.0
682	03-04-1984	05-04-1984	23-04-1984	0.3258	61.0	19.2	11.2	8.0	4.5
683	08-04-1984	09-04-1984	24-05-1984	0.1035	11.2	11.1	2.3	8.8	0.0
684	10-04-1984	16-04-1984	11-09-1984	0.0329	42.7	46.4	6.0	40.5	4.9
685	21-04-1984	22-04-1984	04-06-1984	0.0685	4.8	2.6	0.3	2.3	0.0
686	24-04-1984	26-04-1984	09-05-1984	0.3916	105.8	9.3	7.0	2.4	0.0
687	28-04-1984	30-04-1984	19-05-1984	0.2381	8.3	5.2	2.6	2.6	0.0
688	01-05-1984	03-05-1984	24-06-1984	0.0804	10.4	9.1	1.4	7.7	0.0
689	04-05-1984	13-05-1984	06-06-1984	0.1965	22.5	9.6	3.4	6.2	0.0
690	14-05-1984	17-05-1984	15-08-1984	0.0466	21.7	16.1	2.2	13.9	0.0
691	18-05-1984	18-05-1984	18-06-1984	0.1236	26.7	4.3	1.4	2.9	0.1
692	21-05-1984	26-05-1984	08-06-1984	100.0000	0.2	6.7	0.5	6.2	0.3
693	07-06-1984	08-06-1984	11-06-1984	100.0000	1.3	2.0	2.0	0.0	0.0
694	10-06-1984	15-06-1984	06-07-1984	0.2189	8.0	8.0	3.7	4.2	0.0
695	17-06-1984	22-06-1984	11-07-1984	0.2800	6.1	6.0	1.2	4.9	0.0
696	27-06-1984	01-07-1984	22-08-1984	0.0741	7.6	7.5	1.3	6.2	0.0
697	02-07-1984	04-07-1984	11-07-1984	0.9593	23.2	1.7	0.9	0.8	12.0
698	09-07-1984	11-07-1984	14-07-1984	100.0000	1.0	1.1	1.1	0.0	0.0
699	13-07-1984	16-07-1984	25-07-1984	0.4789	23.5	4.0	3.3	0.7	0.0
700	17-07-1984	25-07-1984	01-08-1984	0.6884	104.9	13.2	12.2	1.0	0.0
701	26-07-1984	30-07-1984	19-08-1984	0.2714	71.9	16.0	8.5	7.4	0.0
702	03-08-1984	05-08-1984	10-01-1985	0.0274	42.9	31.6	4.7	27.0	0.0
703	07-08-1984	10-08-1984	15-09-1984	0.0915	13.3	3.7	1.0	2.7	0.0
704	13-08-1984	16-08-1984	15-10-1984	0.0964	98.8	57.8	19.6	38.2	0.0
705	17-08-1984	21-08-1984	23-08-1984	100.0000	74.5	1.6	1.6	0.0	0.0
706	22-08-1984	24-08-1984	26-08-1984	2.4396	51.7	14.0	13.9	0.0	0.0
707	25-08-1984	27-08-1984	17-11-1984	0.0642	67.0	38.4	10.2	28.2	10.5
708	07-09-1984	09-09-1984	02-03-1985	0.0235	45.5	28.3	3.5	24.7	0.2
709	16-09-1984	18-09-1984	27-09-1984	0.4155	2.1	1.0	0.6	0.4	0.0
710	20-09-1984	21-09-1984	16-10-1984	0.1992	78.1	17.3	11.9	5.4	1.0
711	25-09-1984	28-09-1984	10-10-1984	0.4292	49.2	6.3	4.4	1.8	0.0
712	30-09-1984	04-10-1984	07-10-1984	100.0000	0.4	3.4	3.4	0.0	0.0
713	06-10-1984	08-10-1984	10-11-1984	0.1516	46.3	12.5	3.9	8.7	0.0
714	09-10-1984	10-10-1984	13-10-1984	1.9400	8.1	0.6	0.6	0.0	0.0
715	12-10-1984	22-10-1984	25-11-1984	0.1799	189.1	64.0	41.3	22.6	1.4
716	30-10-1984	03-11-1984	28-11-1984	0.1929	104.7	12.2	6.3	5.9	0.0
717	04-11-1984	08-11-1984	21-12-1984	0.1084	17.4	13.7	3.9	9.8	0.0
718	09-11-1984	15-11-1984	20-12-1984	0.1415	64.0	16.3	5.9	10.4	0.0
719	17-11-1984	20-11-1984	15-12-1984	0.1908	36.1	9.4	4.0	5.4	0.0
720	21-11-1984	22-11-1984	15-12-1984	0.2059	42.8	7.7	3.3	4.4	0.0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
721	25-11-1984	27-11-1984	10-03-1985	0.0484	56.2	42.7	14.0	28.7	0.0
722	01-12-1984	05-12-1984	15-12-1984	0.5780	67.2	11.1	9.1	2.0	0.0
723	07-12-1984	12-12-1984	29-07-1985	0.0237	131.0	126.7	29.0	97.7	0.0
724	13-12-1984	16-12-1984	29-12-1984	0.4855	123.0	26.9	21.5	5.4	0.0
725	17-12-1984	19-12-1984	28-12-1984	0.5413	17.6	6.8	5.8	1.0	0.0
726	20-12-1984	22-12-1984	20-01-1985	0.1872	4.9	10.5	1.6	9.0	5.7
727	27-12-1984	30-12-1984	04-01-1985	0.8512	24.2	3.6	3.4	0.2	0.0
728	31-12-1984	02-01-1985	21-01-1985	0.3454	68.5	29.2	16.9	12.3	0.0
729	03-01-1985	05-01-1985	09-01-1985	1.1221	80.3	4.4	4.4	0.1	0.0
730	06-01-1985	12-01-1985	07-05-1985	0.0492	127.7	81.5	21.5	60.0	0.0
731	13-01-1985	15-01-1985	26-01-1985	0.5700	90.0	17.4	14.6	2.7	0.0
732	17-01-1985	22-01-1985	14-02-1985	0.2503	123.7	23.8	13.3	10.5	0.0
733	23-01-1985	31-01-1985	01-04-1985	0.1001	416.4	180.5	134.7	45.8	0.0
734	01-02-1985	03-02-1985	24-02-1985	0.2151	16.6	6.4	3.1	3.3	0.0
735	04-02-1985	07-02-1985	31-03-1985	0.0873	13.4	12.7	2.4	10.3	0.0
736	08-02-1985	15-02-1985	31-03-1985	0.1241	75.4	33.3	13.9	19.4	0.0
737	16-02-1985	18-02-1985	28-03-1985	0.1156	15.3	8.7	2.7	6.0	46.1
738	23-02-1985	25-02-1985	13-03-1985	0.4039	128.2	35.4	27.8	7.6	0.0
739	26-02-1985	01-03-1985	13-03-1985	0.5267	104.6	42.6	37.2	5.4	0.0
740	02-03-1985	09-03-1985	20-03-1985	0.6578	38.9	38.7	31.6	7.2	0.0
741	11-03-1985	23-03-1985	08-04-1985	0.3621	94.3	55.7	45.4	10.3	0.0
742	25-03-1985	29-03-1985	29-04-1985	0.1795	25.8	25.7	11.5	14.2	0.0
743	30-03-1985	02-04-1985	25-11-1985	0.0254	191.4	191.4	32.6	158.8	0.0
744	05-04-1985	07-04-1985	10-04-1985	1.2615	46.5	0.8	0.8	0.0	0.0
745	08-04-1985	10-04-1985	17-04-1985	0.6255	2.4	2.4	1.9	0.4	0.0
746	11-04-1985	14-04-1985	27-06-1985	0.0773	204.4	63.6	24.8	38.9	8.8
747	18-04-1985	23-04-1985	05-05-1985	0.3861	159.4	33.1	31.3	1.7	0.0
748	24-04-1985	06-05-1985	26-07-1985	0.0643	176.6	53.5	19.9	33.7	0.2
749	10-05-1985	11-05-1985	02-06-1985	0.1999	54.5	8.7	5.8	2.9	0.2
750	14-05-1985	26-05-1985	11-09-1985	0.0400	47.6	27.0	5.8	21.2	0.0
751	27-05-1985	31-05-1985	11-06-1985	0.3514	2.0	2.0	1.1	0.8	0.0
752	01-06-1985	05-06-1985	24-06-1985	0.2854	105.5	15.3	9.2	6.1	0.1
753	09-06-1985	12-06-1985	17-06-1985	1.0188	48.0	11.4	11.2	0.3	0.0
754	13-06-1985	13-06-1985	19-06-1985	100.0000	0.2	6.5	2.9	3.6	0.1
755	18-06-1985	20-06-1985	30-06-1985	0.5025	4.6	4.6	3.5	1.1	0.0
756	21-06-1985	25-06-1985	27-06-1985	100.0000	0.5	3.7	3.7	0.0	0.0
757	26-06-1985	29-06-1985	09-07-1985	100.0000	5.5	12.1	3.5	8.6	2.4
758	08-07-1985	10-07-1985	19-07-1985	0.5234	3.9	3.9	3.0	0.9	0.0
759	11-07-1985	13-07-1985	30-07-1985	0.2756	38.1	7.2	4.7	2.5	0.0
760	14-07-1985	19-07-1985	22-07-1985	100.0000	1.3	4.3	4.3	0.0	0.0
761	21-07-1985	25-07-1985	28-07-1985	100.0000	4.4	5.4	5.4	0.0	0.0
762	27-07-1985	28-07-1985	03-08-1985	100.0000	0.1	5.2	1.9	3.3	0.0
763	02-08-1985	03-08-1985	08-08-1985	0.9009	2.1	2.0	1.8	0.2	0.0
764	04-08-1985	07-08-1985	10-08-1985	100.0000	0.1	3.0	3.0	0.0	0.0
765	09-08-1985	15-08-1985	14-10-1985	0.0784	91.7	21.6	7.7	14.0	0.0
766	21-08-1985	24-08-1985	07-09-1985	0.3308	66.9	5.3	3.3	2.1	0.0
767	25-08-1985	25-08-1985	29-08-1985	100.0000	0.2	0.5	0.5	0.0	0.0
768	28-08-1985	03-09-1985	19-09-1985	0.4235	213.5	40.7	26.4	14.2	0.0
769	04-09-1985	07-09-1985	13-09-1985	0.4857	56.5	7.3	7.1	0.2	0.0
770	08-09-1985	15-09-1985	17-09-1985	100.0000	2.6	5.3	5.3	0.0	0.0
771	16-09-1985	16-09-1985	19-09-1985	100.0000	0.2	1.5	1.5	0.0	0.0
772	18-09-1985	20-09-1985	30-11-1985	0.0607	16.0	13.6	2.1	11.5	0.0
773	21-09-1985	22-09-1985	24-09-1985	1.2311	12.6	0.5	0.4	0.0	0.0
774	23-09-1985	27-09-1985	24-10-1985	0.1150	13.0	2.7	0.8	1.9	0.0
775	28-09-1985	05-10-1985	16-12-1985	0.0496	13.9	8.2	0.8	7.3	0.0
776	07-10-1985	14-10-1985	28-10-1985	0.2628	11.3	2.4	1.0	1.4	0.0
777	18-10-1985	22-10-1985	24-10-1985	2.0979	42.2	0.8	0.8	0.0	0.0
778	23-10-1985	27-10-1985	21-11-1985	0.1538	31.6	5.5	2.6	2.8	0.0
779	28-10-1985	01-11-1985	08-11-1985	0.5230	31.1	1.9	1.6	0.3	0.0
780	02-11-1985	08-11-1985	15-01-1986	0.0692	119.8	36.2	20.3	15.9	0.0
781	15-11-1985	18-11-1985	22-11-1985	0.7361	0.6	0.6	0.5	0.1	0.0
782	19-11-1985	23-11-1985	09-12-1985	0.1993	10.5	2.1	1.0	1.2	0.0
783	24-11-1985	25-11-1985	29-11-1985	1.0338	11.9	1.0	0.9	0.0	0.0
784	26-11-1985	30-11-1985	07-12-1985	0.5530	25.3	3.2	2.8	0.5	0.0
785	01-12-1985	02-12-1985	04-12-1985	100.0000	0.3	0.4	0.4	0.0	0.0
786	03-12-1985	08-12-1985	15-02-1986	0.0627	87.2	18.9	6.8	12.2	0.0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
787	11-12-1985	17-12-1985	08-01-1986	0.1554	57.7	5.3	3.5	1.8	0.0
788	20-12-1985	22-12-1985	24-01-1986	0.0711	1.6	1.5	0.2	1.3	0.0
789	24-12-1985	30-12-1985	02-02-1986	0.1079	72.7	10.0	6.2	3.8	0.0
790	01-01-1986	03-01-1986	07-03-1986	0.0613	11.1	9.0	1.5	7.5	0.0
791	04-01-1986	07-01-1986	17-01-1986	0.1844	32.3	0.7	0.5	0.2	0.0
792	10-01-1986	12-01-1986	26-03-1986	0.0464	29.3	7.9	2.1	5.9	0.1
793	15-01-1986	15-01-1986	18-01-1986	100.0000	0.3	0.4	0.4	0.0	0.0
794	17-01-1986	17-01-1986	01-02-1986	0.2030	3.7	1.6	0.9	0.7	0.0
795	20-01-1986	23-01-1986	08-02-1986	0.2282	40.9	2.4	1.1	1.3	0.0
796	24-01-1986	26-01-1986	01-02-1986	0.6416	15.8	1.4	1.3	0.2	0.0
797	27-01-1986	29-01-1986	27-04-1986	0.0382	2.0	7.4	0.5	6.9	15.8
798	03-02-1986	06-02-1986	13-02-1986	0.7923	184.7	60.1	59.6	0.6	0.0
799	07-02-1986	11-02-1986	12-03-1986	0.1774	61.2	15.3	6.0	9.3	0.0
800	12-02-1986	13-02-1986	18-02-1986	1.1720	86.3	10.2	10.0	0.2	0.0
801	14-02-1986	16-02-1986	26-02-1986	0.6244	23.8	14.6	12.4	2.1	0.0
802	17-02-1986	19-02-1986	27-03-1986	0.1599	24.9	24.9	8.9	16.0	0.0
803	20-02-1986	23-02-1986	27-03-1986	0.1709	63.4	30.7	18.4	12.3	0.0
804	24-02-1986	24-02-1986	27-02-1986	45.8830	1.6	0.8	0.8	0.0	0.0
805	26-02-1986	04-03-1986	24-03-1986	0.2972	149.8	39.5	27.8	11.6	0.0
806	05-03-1986	06-03-1986	15-06-1986	0.0589	68.9	67.6	8.1	59.5	0.0
807	07-03-1986	08-03-1986	11-03-1986	2.0443	33.9	5.3	5.3	0.0	0.0
808	09-03-1986	11-03-1986	02-04-1986	0.2915	45.3	34.2	21.2	13.0	8.1
809	16-03-1986	18-03-1986	26-03-1986	0.7325	9.6	9.5	8.2	1.3	0.0
810	19-03-1986	21-03-1986	26-03-1986	1.1182	146.8	19.9	19.6	0.4	0.0
811	22-03-1986	25-03-1986	23-04-1986	0.2100	29.0	28.9	12.4	16.4	0.0
812	26-03-1986	27-03-1986	04-08-1986	0.0340	30.4	25.0	1.7	23.3	0.0
813	28-03-1986	30-03-1986	14-04-1986	0.2341	10.3	1.9	0.9	1.0	0.0
814	31-03-1986	05-04-1986	08-04-1986	100.0000	2.8	5.3	5.3	0.0	0.0
815	07-04-1986	13-04-1986	22-04-1986	0.5629	75.3	20.5	18.7	1.7	0.0
816	15-04-1986	19-04-1986	16-07-1986	0.0680	177.5	83.6	24.8	58.7	4.3
817	24-04-1986	24-04-1986	07-05-1986	0.3395	18.0	2.5	1.1	1.4	0.3
818	27-04-1986	03-05-1986	07-06-1986	0.1424	139.8	37.8	26.9	10.9	0.0
819	04-05-1986	12-05-1986	22-07-1986	0.0761	40.3	39.4	8.0	31.4	0.0
820	13-05-1986	14-05-1986	02-06-1986	0.2116	31.6	3.3	1.3	1.9	0.0
821	15-05-1986	17-05-1986	05-08-1986	0.0618	25.1	22.4	1.8	20.6	20.8
822	23-05-1986	29-05-1986	20-06-1986	0.2123	7.5	7.5	2.5	5.0	0.0
823	31-05-1986	09-06-1986	04-08-1986	0.0885	52.1	24.6	6.0	18.7	0.0
824	12-06-1986	17-06-1986	10-07-1986	0.2934	20.0	19.8	8.8	11.0	0.1
825	26-06-1986	29-06-1986	25-08-1986	0.0856	37.1	27.0	12.4	14.5	0.0
826	02-07-1986	04-07-1986	10-07-1986	0.9811	97.8	13.6	13.3	0.3	0.0
827	05-07-1986	09-07-1986	23-09-1986	0.0772	112.0	112.1	70.8	41.2	0.0
828	19-07-1986	26-07-1986	27-09-1986	0.0783	150.2	32.6	13.5	19.0	0.0
829	28-07-1986	01-08-1986	30-08-1986	0.1630	26.7	9.5	2.7	6.8	0.0
830	02-08-1986	02-08-1986	13-08-1986	100.0000	0.3	4.0	0.2	3.8	0.0
831	12-08-1986	13-08-1986	02-09-1986	0.2389	5.7	5.6	2.4	3.2	0.0
832	14-08-1986	15-08-1986	18-08-1986	1.8650	45.8	4.8	4.8	0.0	0.0
833	16-08-1986	18-08-1986	14-09-1986	0.1723	8.3	8.3	2.8	5.4	0.0
834	19-08-1986	23-08-1986	01-10-1986	0.1374	71.9	30.4	15.2	15.2	1.6
835	28-08-1986	02-09-1986	08-10-1986	0.1420	22.2	17.1	6.3	10.9	0.0
836	05-09-1986	06-09-1986	27-10-1986	0.1035	14.3	14.2	1.5	12.7	0.0
837	15-09-1986	23-09-1986	27-10-1986	0.1392	132.9	15.6	6.1	9.5	0.0
838	25-09-1986	28-09-1986	04-10-1986	1.1161	147.1	22.6	22.2	0.4	0.0
839	29-09-1986	01-10-1986	09-10-1986	100.0000	7.6	18.4	6.5	11.9	0.1
840	08-10-1986	10-10-1986	12-10-1986	100.0000	4.7	5.8	5.8	0.0	0.0
841	11-10-1986	13-10-1986	15-12-1986	0.0849	34.5	30.5	7.0	23.5	0.0
842	14-10-1986	16-10-1986	26-10-1986	0.3100	4.8	1.3	0.8	0.5	0.0
843	17-10-1986	22-10-1986	27-11-1986	0.1555	111.9	30.8	13.9	16.8	0.0
844	23-10-1986	25-10-1986	27-10-1986	100.0000	1.9	2.1	2.1	0.0	0.0
845	26-10-1986	27-10-1986	30-10-1986	100.0000	0.2	1.6	1.6	0.0	0.0
846	29-10-1986	01-11-1986	04-11-1986	100.0000	2.3	4.4	4.4	0.0	0.0
847	03-11-1986	04-11-1986	17-11-1986	0.4004	6.3	6.3	3.6	2.6	0.0
848	06-11-1986	10-11-1986	14-02-1987	0.0590	183.3	71.7	22.6	49.1	0.0
849	11-11-1986	15-11-1986	29-05-1987	0.0273	175.1	125.0	49.6	75.4	0.0
850	24-11-1986	26-11-1986	30-11-1986	1.8955	58.4	2.3	2.3	0.0	0.0
851	29-11-1986	03-12-1986	13-12-1986	0.5543	104.2	25.8	23.5	2.3	0.0
852	04-12-1986	06-12-1986	03-02-1987	0.0759	15.0	13.8	2.9	10.9	0.0

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
853	07-12-1986	13-12-1986	22-01-1987	0.1393	107.9	34.5	15.8	18.8	1.9
854	18-12-1986	20-12-1986	24-12-1986	1.6188	190.0	35.5	35.4	0.1	0.0
855	21-12-1986	25-12-1986	09-01-1987	0.4015	63.0	33.4	27.3	6.1	0.0
856	26-12-1986	28-12-1986	30-12-1986	100.0000	1.4	6.8	6.8	0.0	0.0
857	29-12-1986	01-01-1987	12-01-1987	0.5408	58.0	26.2	23.7	2.6	0.0
858	02-01-1987	05-01-1987	19-01-1987	0.3990	47.2	20.1	15.6	4.5	0.0
859	06-01-1987	11-01-1987	13-01-1987	100.0000	1.7	16.1	16.1	0.0	0.0
860	12-01-1987	15-01-1987	24-02-1987	0.1493	34.6	34.6	12.5	22.1	0.0
861	17-01-1987	20-01-1987	14-05-1987	0.0473	115.8	59.8	13.1	46.7	0.1
862	23-01-1987	26-01-1987	03-02-1987	0.7765	127.2	92.8	90.9	1.9	0.0
863	27-01-1987	01-02-1987	13-03-1987	0.1601	133.8	98.9	64.3	34.6	0.0
864	03-02-1987	04-02-1987	21-02-1987	0.2771	24.7	4.9	2.5	2.4	0.0
865	05-02-1987	06-02-1987	01-03-1987	0.2033	9.0	6.0	2.3	3.7	0.0
866	08-02-1987	11-02-1987	06-03-1987	0.2786	124.2	50.9	34.5	16.4	0.0
867	12-02-1987	15-02-1987	24-02-1987	0.5544	36.4	18.3	17.0	1.2	0.0
868	16-02-1987	21-02-1987	30-05-1987	0.0663	128.4	128.4	32.9	95.5	0.6
869	03-03-1987	03-03-1987	06-03-1987	100.0000	0.1	0.5	0.5	0.0	0.0
870	05-03-1987	11-03-1987	24-05-1987	0.0769	110.0	45.7	7.9	37.9	0.2
871	15-03-1987	19-03-1987	24-03-1987	100.0000	81.5	115.5	106.3	9.2	0.0
872	23-03-1987	24-03-1987	04-04-1987	100.0000	0.4	22.3	3.6	18.7	10.1
873	03-04-1987	05-04-1987	30-04-1987	0.2731	164.6	52.2	30.1	22.1	0.0
874	06-04-1987	08-04-1987	10-04-1987	44.8961	41.0	2.4	2.4	0.0	0.0
875	09-04-1987	12-04-1987	03-06-1987	0.1007	39.0	26.2	5.8	20.4	0.0
876	13-04-1987	16-04-1987	23-04-1987	0.9838	8.9	8.8	7.8	1.0	0.0
877	18-04-1987	26-04-1987	03-06-1987	0.1561	41.5	41.4	13.6	27.8	0.0
878	27-04-1987	29-04-1987	06-05-1987	0.4797	15.3	1.4	1.2	0.2	0.0
879	30-04-1987	08-05-1987	03-06-1987	0.0741	49.4	43.4	7.6	35.8	0.0
880	09-05-1987	11-05-1987	23-05-1987	0.3708	58.3	5.8	4.3	1.5	0.0
881	12-05-1987	13-05-1987	30-05-1987	0.2373	5.0	3.0	1.2	1.7	0.0
882	15-05-1987	19-05-1987	03-06-1987	0.0600	82.8	43.0	20.4	22.6	0.0
883	20-05-1987	22-05-1987	29-05-1987	0.8190	79.3	23.6	23.0	0.5	0.0
884	24-05-1987	29-05-1987	03-06-1987	0.1697	112.9	27.8	21.7	6.1	0.0
885	30-05-1987	02-06-1987	15-10-1987	0.0825	7.7	25.0	4.3	20.7	481.3
886	17-08-1987	25-08-1987	19-11-1987	0.0372	81.7	30.7	5.0	25.6	0.3
887	29-08-1987	04-09-1987	21-10-1987	0.0892	63.0	15.1	7.5	7.5	0.0
888	05-09-1987	08-09-1987	19-11-1987	0.0175	14.5	11.2	1.6	9.6	0.0
889	10-09-1987	14-09-1987	23-09-1987	0.4958	74.3	8.9	7.8	1.2	0.0
890	15-09-1987	19-09-1987	29-09-1987	0.5078	65.2	9.0	7.1	1.9	0.0
891	20-09-1987	25-09-1987	19-11-1987	0.0565	142.9	67.0	15.0	52.0	26.2
892	02-10-1987	04-10-1987	08-10-1987	1.4685	126.0	8.9	8.8	0.1	0.0
893	06-10-1987	08-10-1987	10-11-1987	0.1577	19.1	19.1	8.8	10.3	0.0
894	10-10-1987	13-10-1987	15-10-1987	100.0000	0.9	1.8	1.8	0.0	0.0
895	14-10-1987	18-10-1987	19-11-1987	0.1751	87.2	25.7	10.5	15.1	0.0
896	19-10-1987	24-10-1987	01-11-1987	0.6424	106.7	14.7	13.7	1.1	0.0
897	25-10-1987	30-10-1987	19-11-1987	0.2095	34.5	30.2	4.3	25.9	0.0
898	07-11-1987	11-11-1987	19-11-1987	0.0346	64.8	14.7	3.5	11.2	0.0
899	12-11-1987	17-11-1987	19-11-1987	0.4849	18.3	4.0	4.0	0.0	0.0
900	18-11-1987	18-11-1987	30-11-1987	0.4849	0.1	0.5	0.5	0.0	44.0

Annex 3 – Separation of surface flow into direct runoff and base flow for the Cubatão watershed

# Episode	Precipitation starting	Last possible day of precipitation	Last day of surface flow	Recession coefficient	Precipitation	Surface flow	Direct runoff	Base flow	Precipitation till the starting of the next episode
1	01-11-1966	05-11-1966	13-11-1966	100.0000	241.8	126.4	84.9	41.5	0.0
2	12-11-1966	14-11-1966	19-01-1967	0.1071	89.0	190.4	55.9	134.6	116.9
3	20-11-1966	24-11-1966	03-12-1966	100.0000	17.6	38.3	25.7	12.6	0.0
4	02-12-1966	03-12-1966	04-01-1967	0.2405	9.7	30.6	3.7	26.9	21.0
5	15-12-1966	18-12-1966	04-01-1967	0.3241	57.7	16.0	9.9	6.1	0.0
6	20-12-1966	25-12-1966	28-12-1966	100.0000	536.3	661.1	661.1	0.0	0.0
7	27-12-1966	27-12-1966	15-03-1967	0.0841	6.3	96.6	17.4	79.2	91.0
8	06-01-1967	07-01-1967	06-10-1967	0.0207	81.2	142.7	13.0	129.7	70.2
9	10-01-1967	12-01-1967	26-01-1967	0.6581	120.8	53.2	28.6	24.5	151.0
10	19-01-1967	21-01-1967	07-02-1967	0.3678	58.0	23.4	15.7	7.7	0.0
11	22-01-1967	27-01-1967	13-02-1967	0.3951	207.9	71.1	57.5	13.5	0.0
12	28-01-1967	30-01-1967	01-02-1967	6.5419	15.4	14.7	14.7	0.0	0.0
13	31-01-1967	31-01-1967	03-02-1967	100.0000	0.5	12.7	12.7	0.0	0.0
14	02-02-1967	03-02-1967	28-02-1967	0.2642	38.6	38.2	18.2	20.1	0.0
15	04-02-1967	07-02-1967	15-03-1967	0.1836	215.3	177.1	143.0	34.1	0.0
16	09-02-1967	10-02-1967	05-03-1967	0.2710	73.4	25.6	12.8	12.8	0.0
17	11-02-1967	15-02-1967	27-02-1967	0.5257	162.6	54.4	50.3	4.1	0.0
18	16-02-1967	20-02-1967	13-03-1967	0.3675	272.8	184.4	146.9	37.5	0.0
19	23-02-1967	25-02-1967	15-03-1967	0.3513	23.2	23.1	12.2	10.9	0.0
20	27-02-1967	27-02-1967	02-03-1967	6.3144	13.0	11.5	11.5	0.0	0.0
21	01-03-1967	04-03-1967	18-03-1967	0.4921	98.3	86.8	75.1	11.6	0.0
22	05-03-1967	08-03-1967	10-03-1967	100.0000	52.0	85.7	85.7	0.0	0.0
23	09-03-1967	10-03-1967	12-03-1967	100.0000	61.8	70.0	70.0	0.0	0.0
24	11-03-1967	13-03-1967	15-03-1967	100.0000	14.0	28.5	28.5	0.0	0.0
25	14-03-1967	16-03-1967	18-03-1967	100.0000	48.7	55.7	55.7	0.0	0.0
26	17-03-1967	19-03-1967	21-03-1967	100.0000	120.0	150.8	150.8	0.0	0.0
27	20-03-1967	21-03-1967	02-04-1967	0.6606	58.8	58.5	48.4	10.1	0.0
28	23-03-1967	24-03-1967	26-03-1967	6.5911	11.8	11.1	11.1	0.0	0.0
29	25-03-1967	27-03-1967	31-03-1967	100.0000	23.1	41.5	41.5	0.0	5.8
30	30-03-1967	30-03-1967	15-04-1967	100.0000	1.1	57.0	8.8	48.2	0.0
31	14-04-1967	16-04-1967	22-04-1967	100.0000	62.4	72.8	57.5	15.4	8.5
32	21-04-1967	21-04-1967	26-04-1967	100.0000	5.1	11.9	4.9	7.0	1.0
33	25-04-1967	26-04-1967	08-06-1967	0.1550	137.8	76.2	36.9	39.4	7.5
34	02-05-1967	08-05-1967	20-05-1967	100.0000	1.0	20.0	4.7	15.3	0.0
35	19-05-1967	21-05-1967	21-07-1967	0.1086	62.5	62.3	18.9	43.4	0.0
36	04-06-1967	06-06-1967	21-06-1967	0.4143	49.4	16.4	9.4	7.0	0.0
37	10-06-1967	14-06-1967	07-09-1967	0.0680	100.5	100.3	52.2	48.1	0.0
38	24-06-1967	26-06-1967	19-08-1967	0.1076	19.4	19.3	1.9	17.4	0.0
39	09-07-1967	12-07-1967	29-07-1967	0.3984	122.5	46.2	35.4	10.8	0.0
40	16-07-1967	17-07-1967	22-07-1967	100.0000	3.3	8.5	4.9	3.5	0.0
41	21-07-1967	22-07-1967	30-07-1967	100.0000	10.8	22.9	14.4	8.5	0.0
42	29-07-1967	05-08-1967	15-08-1967	1.0688	68.4	43.7	20.4	23.3	0.0
43	11-08-1967	26-08-1967	03-09-1967	100.0000	4.0	34.8	16.4	18.4	0.0
44	02-09-1967	11-09-1967	02-10-1967	0.3525	46.1	70.9	29.1	41.9	63.6
45	18-09-1967	25-09-1967	13-10-1967	0.3388	72.5	50.3	38.6	11.7	0.0
46	26-09-1967	27-09-1967	13-10-1967	100.0000	2.9	30.4	3.3	27.0	16.5
47	12-10-1967	12-10-1967	30-10-1967	0.3316	70.0	10.6	5.0	5.6	0.0
48	14-10-1967	15-10-1967	17-10-1967	6.4141	3.2	2.7	2.7	0.0	0.0
49	16-10-1967	20-10-1967	07-11-1967	0.3135	42.9	22.1	16.1	6.1	0.0
50	21-10-1967	27-10-1967	31-10-1967	100.0000	26.1	138.6	138.6	0.0	16.7
51	30-10-1967	30-10-1967	04-11-1967	100.0000	23.3	32.9	23.1	9.8	0.0
52	03-11-1967	06-11-1967	11-11-1967	100.0000	38.9	57.7	43.7	13.9	0.0
53	10-11-1967	15-11-1967	29-11-1967	0.4814	55.3	54.9	43.5	11.4	0.0
54	16-11-1967	20-11-1967	22-11-1967	100.0000	90.5	110.2	110.2	0.0	0.0
55	21-11-1967	22-11-1967	26-11-1967	100.0000	25.4	41.6	41.6	0.0	9.7
56	25-11-1967	29-11-1967	04-12-1967	100.0000	33.3	113.4	79.0	34.4	0.0
57	03-12-1967	04-12-1967	27-01-1968	0.1307	108.5	108.5	36.0	72.5	0.0
58	09-12-1967	10-12-1967	20-12-1967	0.6261	50.0	14.1	10.9	3.2	0.0

59	12-12-1967	14-12-1967	18-12-1967	100.0000	9.0	10.6	10.6	0.0	0.0
60	17-12-1967	18-12-1967	01-05-1968	0.0408	44.0	73.0	5.4	67.6	28.0
61	21-12-1967	21-12-1967	24-12-1967	100.0000	1.8	6.9	6.9	0.0	0.0
62	23-12-1967	24-12-1967	30-12-1967	100.0000	2.7	20.7	10.5	10.2	10.4
63	29-12-1967	01-01-1968	04-01-1968	100.0000	18.7	38.9	38.9	0.0	0.0
64	03-01-1968	05-01-1968	04-02-1968	0.2134	51.6	36.4	16.2	20.2	1.4
65	12-01-1968	16-01-1968	12-02-1968	0.1872	23.0	13.3	6.3	7.0	0.0
66	17-01-1968	19-01-1968	27-01-1968	0.8512	60.4	20.1	18.7	1.4	0.0
67	20-01-1968	23-01-1968	31-01-1968	100.0000	39.0	44.2	25.7	18.5	4.0
68	30-01-1968	31-01-1968	15-02-1968	100.0000	5.3	113.6	69.4	44.2	0.0
69	14-02-1968	16-02-1968	23-02-1968	100.0000	10.4	16.9	6.4	10.5	0.0
70	22-02-1968	25-02-1968	02-03-1968	100.0000	20.5	24.4	16.4	8.0	0.0
71	01-03-1968	04-03-1968	19-03-1968	0.3900	17.0	14.3	9.7	4.6	0.0
72	06-03-1968	08-03-1968	11-03-1968	100.0000	1.3	3.8	3.8	0.0	0.0
73	10-03-1968	13-03-1968	22-04-1968	0.1468	63.0	33.1	12.6	20.5	0.0
74	15-03-1968	18-03-1968	22-04-1968	0.2051	216.2	98.8	60.7	38.0	57.6
75	28-03-1968	31-03-1968	01-05-1968	0.0661	188.6	167.0	94.8	72.1	0.0
76	01-04-1968	06-04-1968	12-04-1968	2.1987	536.4	106.7	99.4	7.3	5.0
77	11-04-1968	14-04-1968	18-04-1968	45.1571	27.2	3.0	3.0	0.0	1.1
78	17-04-1968	21-04-1968	29-04-1968	0.9985	101.7	31.4	27.3	4.0	0.0
79	24-04-1968	25-04-1968	01-05-1968	100.0000	5.0	11.7	4.3	7.4	1.0
80	30-04-1968	30-04-1968	10-06-1968	100.0000	1.0	17.0	1.5	15.5	232.6
81	09-06-1968	10-06-1968	20-08-1968	0.0948	13.0	57.9	4.1	53.8	45.0
82	26-06-1968	26-06-1968	11-07-1968	0.2224	9.0	1.1	0.3	0.7	0.0
83	01-07-1968	06-07-1968	16-07-1968	0.6695	50.0	16.9	12.0	4.9	0.0
84	10-07-1968	10-07-1968	29-07-1968	0.2887	86.3	8.4	3.4	4.9	3.5
85	15-07-1968	28-07-1968	02-08-1968	100.0000	5.8	19.9	11.2	8.7	2.0
86	01-08-1968	05-08-1968	24-08-1968	100.0000	50.0	35.3	6.5	28.8	0.0
87	23-08-1968	24-08-1968	04-09-1968	100.0000	38.5	63.0	48.1	14.8	0.0
88	03-09-1968	03-09-1968	14-09-1968	100.0000	33.0	13.9	4.6	9.3	0.0
89	13-09-1968	15-09-1968	01-10-1968	100.0000	24.0	80.4	41.3	39.1	0.0
90	30-09-1968	30-09-1968	10-10-1968	0.1215	70.0	16.3	4.5	11.8	0.0
91	08-10-1968	10-10-1968	12-10-1968	46.2636	40.9	1.4	1.4	0.0	0.0
92	11-10-1968	13-10-1968	18-10-1968	100.0000	32.2	39.0	28.0	11.0	0.0
93	17-10-1968	18-10-1968	01-01-1969	0.0822	117.9	61.5	11.8	49.7	8.0
94	28-10-1968	28-10-1968	12-11-1968	100.0000	8.0	16.6	2.3	14.2	7.5
95	11-11-1968	12-11-1968	29-11-1968	100.0000	6.3	57.3	11.0	46.2	6.8
96	28-11-1968	29-11-1968	08-02-1969	0.0783	2.2	37.0	5.8	31.2	73.0
97	02-12-1968	04-12-1968	01-01-1969	0.2082	219.0	25.4	12.4	13.0	0.0
98	06-12-1968	06-12-1968	26-12-1968	100.0000	3.6	30.6	3.9	26.7	0.0
99	25-12-1968	27-12-1968	02-01-1969	1.1098	160.0	16.2	15.2	1.0	0.0
100	29-12-1968	30-12-1968	09-02-1969	0.1424	146.0	31.7	13.0	18.7	0.0
101	03-01-1969	04-01-1969	09-04-1969	0.0179	59.6	46.8	4.4	42.4	0.0
102	08-01-1969	08-01-1969	01-02-1969	0.3194	3.3	16.2	0.7	15.6	47.0
103	22-01-1969	24-01-1969	04-03-1969	0.1411	54.0	49.1	30.2	18.9	2.0
104	31-01-1969	04-02-1969	13-03-1969	0.1556	133.8	63.1	48.2	14.9	0.0
105	14-02-1969	15-02-1969	24-02-1969	0.4806	15.0	1.9	1.3	0.6	0.0
106	17-02-1969	23-02-1969	02-03-1969	100.0000	31.4	126.9	101.4	25.6	0.0
107	01-03-1969	03-03-1969	17-03-1969	0.5023	58.3	40.0	31.6	8.4	11.0
108	06-03-1969	08-03-1969	11-03-1969	100.0000	41.9	48.3	48.3	0.0	0.0
109	10-03-1969	13-03-1969	28-03-1969	100.0000	82.2	101.0	46.0	55.0	0.0
110	27-03-1969	03-04-1969	11-04-1969	47.3355	141.5	80.0	41.9	38.1	100.2
111	10-04-1969	12-04-1969	25-04-1969	100.0000	82.0	88.0	48.6	39.4	0.0
112	24-04-1969	25-04-1969	29-05-1969	100.0000	44.5	57.3	14.3	43.0	0.0
113	28-05-1969	29-05-1969	03-06-1969	100.0000	0.5	29.5	24.1	5.4	0.0
114	02-06-1969	02-06-1969	19-06-1969	100.0000	33.0	34.1	18.0	16.1	0.0
115	18-06-1969	21-06-1969	30-06-1969	0.3622	116.3	26.3	10.1	16.2	0.0
116	30-06-1969	30-06-1969	30-06-1969	0.3622		0.2	0.0	0.2	0.0