SIMULATION BASED PERFORMANCE EVALUATION
OF
AN URBAN WATER DISTRIBUTION NETWORK

A DISSERTATION

Submitted in partial fulfillment of the
requirements for the award of the degree
of
MASTER OF TECHNOLOGY
in
WATER RESOURCES DEVELOPMENT

By

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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this dissertation entitled, "***Simulation Based Performance Evaluation of an Urban Water Distribution Network*** ", in partial fulfillment of requirement for award of the degree of ***Master of Technology in Water Resources Development (Civil)***, submitted in Water Resource Development and Management Department, Indian Institute of Technology, Roorkee, is an authentic record of my own work, carried out during the period from July 2004 till the date of submission under the supervision of **Dr. M. L. Kansal,** Associate Professor, WRD&M Department, Indian Institute of Technology Roorkee (India).

I have not submitted the matter embodied in this dissertation for the award of any other degree or diploma.

Place : Roorkee
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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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HERU SETIADI

ABSTRACT

Performance of a Water Distribution Network (WDN) can be studied in terms of mechanical, hydraulic and water quality reliability. Here, mechanical reliability is the ability of distribution network components to provide continuing and long-term operation without the need for frequent repair, modifications, or replacement of components or subcomponents. Hydraulic reliability can be defined as the probability that the system can provide the demanded flow rate at the required pressure head. Water quality reliability can be defined as the ability to predict the water quality changes during transmission. Due to the random nature of pipeline failure, and future water demands, pressure heads and water quality changes throughout the networks under normal and abnormal conditions. Thus, the estimation of water distribution networks reliability is subjected to uncertainty. In the present study, performance of a WDN has been carried out. A methodology is presented to estimate the nodal and system hydraulic reliabilities of water distribution networks that accounts for these uncertainties. The framework for the methodology is based upon a Monte Carlo simulation consisting of three major components, i.e., random generation of nodal demands, hydraulic and water quality simulation under normal and abnormal conditions using a hydraulic simulator (EPANET), and computation of performance indices. The methodology is discussed with the help of an illustrative water distribution network consisting of 21 pipes and 17 demand nodes.

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CHAPTER 1

INTRODUCTION

1.1. GENERAL

Water distribution networks (WDNs) are designed for the purpose of conveying water in the required quantity and quality at different locations and at different times. The demand for water changes in space and time. Further, the components of WDN are subject to failure. Under these circumstances, it is desired to quantify the performance of water distribution network to (a) design new distribution system or extensions for the existing systems, (b) decide on to upgrade a system with new overhead tanks, etc., and (c) revamp the system. Methods of performance evaluation of WDNs can be classified in two categories : (1) analytical methods, and (2) simulations methods. In analytical techniques, one determine the reliability of networks by using analytical tools like that of pathsets/ cutsets enumeration, network reduction, analysis of capacitated network, etc. Analytical methods developed for water distribution networks are based on similar works done in the fields of electrical and mechanical engineering. In these fields, there are only two states for a system; either a working condition or a failure, hence shutdown condition. Therefore, analytical methods developed for analysis and design of water distribution networks also considered two states : working condition and shutdown condition. Many analytical method presume that when a demand node is connected to a source node, demand at the node is satisfied. Even though this is true for mechanical components such as pump and valves in a water distribution network, this two-state functioning is not applicable to the network, as a whole. In between these two states, a partial-functioning state exists. For example, when a pipe breaks, it is in a failure condition; however, when it is in a working condition, its carrying capacity may be less than the design capacity thereby functioning in a partial working condition. Similarly, the discharge or the pressure at a node may be less than the desired value giving partial working condition. In fact, water distribution network, as a whole, are either in completely working condition satisfying the demands completely at all node; or in partial working condition in which water is available at some nodes satisfying the demand completely, while at the remaining nodes water is available partially, or not at all. Therefore, simulation techniques, one estimate the performance of WDN under various conditions by simulating the situation and then arrives at -how poor and how good the system is used to incorporate the partial working condition. Further, the water may be supplied to the consumers either continuously for all the 24 hours of the day, or it may be supplied intermittently during certain fixed hours of the day.

Because of the existence of design and operation uncertainties, water distribution network has an associated risk or probability of failure and an associated reliability or probability of not failing. The measure of the system effectiveness to work under uncertainty of various parameters is known as performance reliability of the system. Here, *Reliability R(t) of component is defined as the probability that the component does not fail between time interval 0 and t, given that it is new or repaired at time zero. Values of reliability lie between 0 and 1.*

Distribution networks have inherent reliability due to their grid-like layout, which is usually a result of the road layout, and the use of service reservoirs throughout of the system. However, a large number of factors affect the reliability of a particular network. These can be split into design, operational and maintenance considerations. Design includes choice of materials, sizes and location of the components. Operational factors are associated with monitoring of failures, surge minimisation and personnel training. The last consideration, maintenance, is ensuring proper functionality of the components and proper choice and implementation of rehabilitation works.

There is no universal agreement on how to define or measure the reliability of a water distribution network, or as to what should be included in this measure. The ability to supply the required water to all locations is made more difficult in the light of spatial and temporal variability that exists in the various network descriptors, for example, those associated with component deterioration.

The reliability of water distribution network is concerned with three type of failure, namely mechanical failure, hydraulic failure and water quality failure. Mechanical failure considers system failure due to pipe breakage, pump failure, power outages, control valve failure, etc. Hydraulic failure considers system failure due to delivered flow and pressure head being inadequate at one or more demand points. These hydraulic failures may be due to changes in demand and pressure head requirements, inadequate pipe sizes, old pipes with varying roughness, insufficient pumping capacity, insufficient storage capability, or any combination of these. Water quality failure considers system failure due to residual disinfection level below the minimum residual level at all nodes of the system.

Since neither the mechanical measure, the hydraulic measure nor the water quality measure alone are adequate to measure the system reliability, it seems reasonable to unify the hydraulic and mechanical failure definitions. It can be done by specifying the reliability as the probability that the given demand nodes in the system receive sufficient supply with satisfactory pressure head or to unify the water quality and mechanical failure definitions as the probability of receiving residual disinfection level within the desired range at all nodes of the system. A nodal reliability is defined as the probability that a given demand node receives sufficient water flow rate with adequate water pressure head or the probability that a given demand node receives residual disinfection level within the desired range. These concepts of failure can be incorporated into a joint reliability definition.

Mechanical reliability is the ability of distribution network components to provide continuing and long-term operation without the need for frequent repair, modifications, or replacement of components or subcomponents. Thus mechanical reliability is usually defined as the probability that a component or subcomponent performs it mission within specified limit for a given period of time in a specified environment. When quantified, mechanical reliability is merely an expression of the probability that a piece of equipment is operational at any given time (Bao *et al*, 1990).

Hydraulic reliability is a measure of the performance of the water distribution network. The hydraulic performance of the distribution system depends to a great degree on the following factors : (1) Interaction between the piping system, distribution storage, distribution pumping and system appurtenances such as pressure reducing valves, check valve, etc.; (2) reliability of the individual system components; (3) spatial variation of demands in the system; (4) temporal variation in demands on the system. In addition, since the demand is spatially and temporally distributed, hydraulic performance at critical locations in the distribution system may be more important than the average system reliability (Cullinane 1989)[3].

Water quality reliability can be defined as the ability to predict the water quality changes during transmission. Purpose of water quality reliability is to preserve the water quality throughout the distribution network. Factors that influence water quality changes during transmission include : (1) Water quality characteristics (chemical, physical, and biological); (2) pipeline characteristics (age, type, tuberculation, corrosion, deposits, etc.); (3) network system characteristics (loops, dead-ends, storage tanks, etc); (4) network operating characteristics (water demands, velocities, etc.); and (5) mixing of waters (different source waters) (Marco *et al.*).

Consideration of reliability in water distribution network has received increasing attention over the past few years. Reliability of water distribution system concerns with the ability of the network to provide an adequate supply to consumers with acceptable quality, under both normal and abnormal operating conditions. Most of research works in the probabilistic aspects of reliability of distribution networks can be separated into two groups. The first group includes those approaches and models that address the reliability of the system as a whole. These approaches examine the reliability of the major components, namely, the supply, the treatment, and the distribution stages, in terms of the performance of overall system. The approaches and models in the second group are directed at the reliability of specific components of the distribution network. The present work falls in both groups. Using three parameters, namely, overall system hydraulic reliability, overall system quality reliability and network effectiveness index are applied the reliability concepts in network analysis.

Generally, two or more pipes fail simultaneously are small and engineers always neglect it when they computed overall system reliability. On the other side the nodal demand often change due to many factors such as new users or an increase in the number of existing users. Because of those conditions, therefore, in this work, probability occurrence of the system is used to calculation carefulness and the geometric mean is proposed to combine nodal reliabilities to assure the overall system hydraulic and quality reliability for evaluated the performance of water distribution network under the failure of a single link in the system.

1.2. OBJECTIVES AND METHODOLOGY OF THE PRESENT STUDY

The objectives of the present study are:

1. To study the various parameters used in quantifying the performance of WDNs.
2. To generate/ estimate the future demands at various demand nodes in the water distribution network using Monte Carlo simulation.
3. To estimate the probability of pipeline availability (mechanical reliability) for an existing water distribution network.
4. To estimate the hydraulic reliability in terms of pressure head at various nodes for various conditions of network availability under average demand condition.
5. To assess the hydraulic reliability under uncertainty of future demands.
6. To evaluate the water quality at each demand node under normal and abnormal conditions.
7. To assess overall nodal and/or system reliability with three parameters, namely : overall system hydraulic reliability, overall system quality reliability and network effectiveness index.

In order to estimate the performance of a water distribution network and to meet the above-mentioned objectives, an algorithm as mentioned in Fig. 1.1 has been proposed. In the proposed algorithm, a network model represents water distribution network. This model depicts the pipeline system and source.

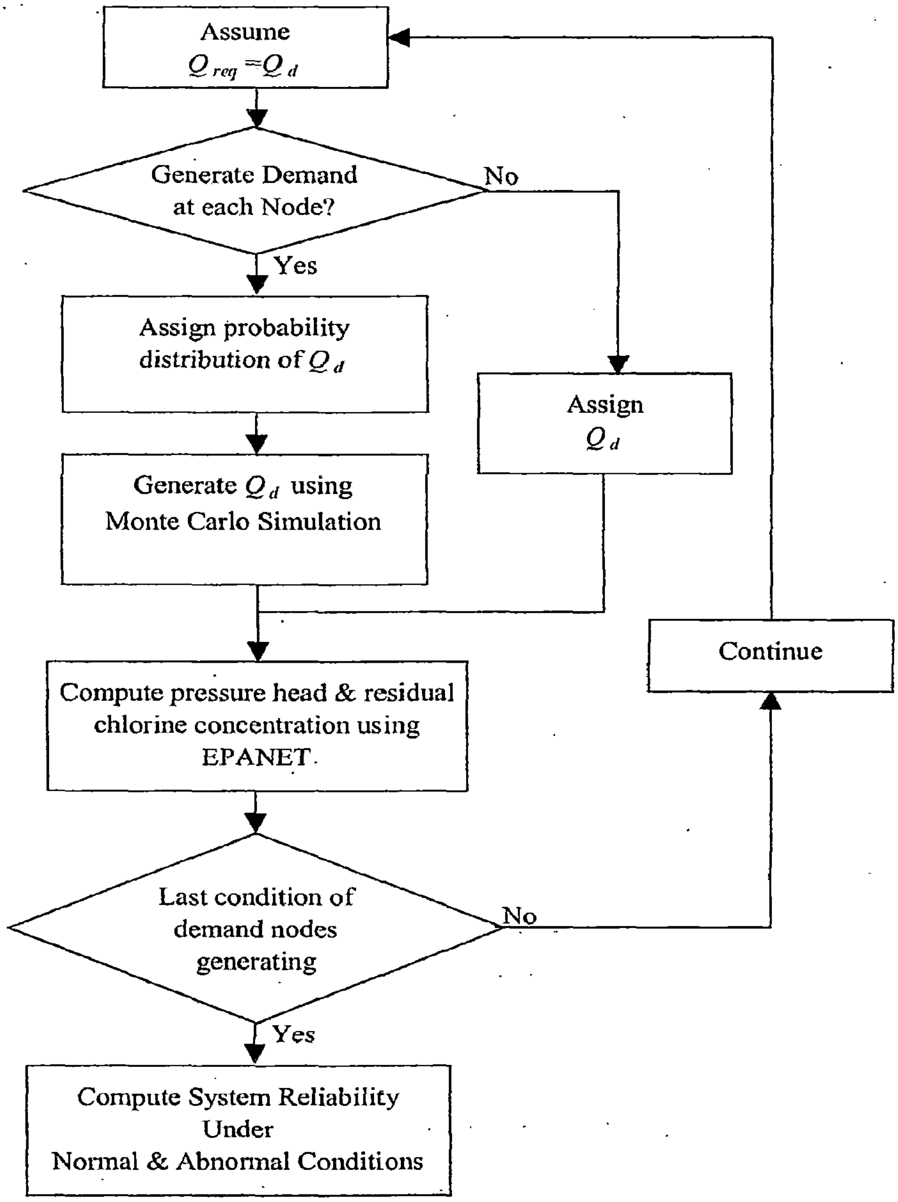


Figure 1.1. Flowchart of Algorithm to Evaluate System Reliability

The analysis consist of following three parts :

(1). In the first part, the random number generator is the central part, wherein, one generate demand at each node according to specified probability distribution.

(2). In the second part, hydraulic and water quality simulator is main part, wherein, one simulates the flows throughout the network, and estimate the pressure heads and the residual disinfectant level at each node for a specified demand under normal and abnormal conditions.

(3). In the third part, reliability assessment to evaluate performance of water distribution network is carried out.

In order to follow the proposed algorithm, as mentioned above, the first part is to estimate the water demand at various nodes in the WDN. Since the demands are probabilistic in nature, it is assumed that the demands follow a Normal probability distribution. Monte Carlo simulation technique is used for generating the demands at various nodes. Once the demands at various nodes are generated, hydraulic and water quality analysis is carried out using EPANET, a program developed by the Water Supply and Water Resources Division of the U.S Environmental Protection Agency (EPA) National Risk Management Research Laboratory, USA. From the results of simulation, performance of WDN is carried out in terms of node reliability, overall system reliability, and in terms of network effectiveness index.

1.3. ORGANIZATION OF THESIS

The present study is organized in following chapters: ***Introduction, Components of WDN, Hydraulic and Water Quality Modelling using EPANET, Network Performance and Reliability Analysis*** and ***Conclusions.***

Introduction (Chapter 1) emphasizes the importance of evaluation of water distribution networks in general, followed by associated problems so as to define objectives and purposes. It is concluded by scope of study presented in this dissertation.

Components of Water Distribution Network (Chapter 2) describes the type of water distribution components including the source of water and treatment scheme. Disinfection practice, to make water free from disease causing pathogens, is an indispensable part of every drinking water treatment. Need for disinfection, types of disinfection role in treatment plant and in the distribution system have been explained in this chapter. The components of water distribution network have been discussed under three major components, viz., pumping stations, distribution storage and distribution piping.

Hydraulic and Water Quality Modelling using EPANET (Chapter 3) presents hydraulic and water quality analysis of turbulent flow of water in closed conduits (pipe) flowing full. Flow in a pipe can either be steady or unsteady flow. In the present study; only steady flow has been reviewed. The steady flow has been described by the continuity and energy equations and head loss. Water quality changes occurring in a water distribution network are directly related to hydraulic characteristics of flow in the system. So, the basic equation of mixing at nodes and advective transport of water borne substances in pipes also have been described.

Recent developments in computer software now provide a capability to build representative models, which can simulate the pressure and concentration of water quality parameters under steady conditions. The hydraulic and water quality simulation features of the model used, EPANET 2.0 (Rossman, 2000) have been briefly described in this chapter. A typical looped water distribution network with source node is selected for illustrating the hydraulic and water quality simulation of a water distribution network using EPANET.

Network Performance and Reliability Analysis (Chapter 4) have been described network performance and reliability analysis for evaluate the system. The pipe failure affects the hydraulic characteristics in the water distribution network, changing the residence time in pipes due to changed route of water. In this chapter, the probability of changing the hydraulic pressure at various nodes is analyzed under normal and abnormal conditions. The Monte Carlo simulation is used for estimating under abnormal conditions has been discussed in this chapter. The failure of pipe also has potential to affect the chlorine concentration reaching the nodes of water distribution network. As residual chlorine concentration reaching the nodes of the water distribution network depends on the decay time, it is possible that some of the nodes, this concentration level may fall below the minimum desired level. The probability of receiving the desired residual chlorine concentration at various nodes is also analyzed in this chapter.

The final chapter ***Conclusions*** (5) summarizes the main conclusions and also suggest suggestions for further research.

CHAPTER 2

COMPONENTS OF WATER DISTRIBUTION NETWORK

2.1. INTRODUCTION

Water distribution system typically consists of a network containing large number of interconnecting pipes with occasional control valves. Reservoirs are connected at strategic points throughout the network to provide storage capacity and maintain required hydraulic pressure for consumer water demands. Rivers, lakes and tube wells are the usual sources of water supply, which is treated before being supplied to the consumers. A typical water supply scheme thus can be broadly sub-divided into two basic systems, which are:

1. Source, Treatment and Clear-water storage System.
2. Pumping, Distribution Storage and Distribution System.

Conventional methods of treatment include aeration, coagulation, sedimentation, softening, filtration and disinfection, though other treatment units may be required according to the deviation of raw water quality from standards. Figure 2.1 illustrates a typical municipal water utility showing the water distribution system as a part of this overall water utility. The selection of operations to be included in a treatment scheme is controlled by quality of source water. The nature and extent of treatment will depend upon the type and concentration of pathogens and other impurities. Disinfection treatment is indispensable in a drinking water treatment plant due to its importance in controlling microbiological quality and preventing transmission of disease through the agency of water.

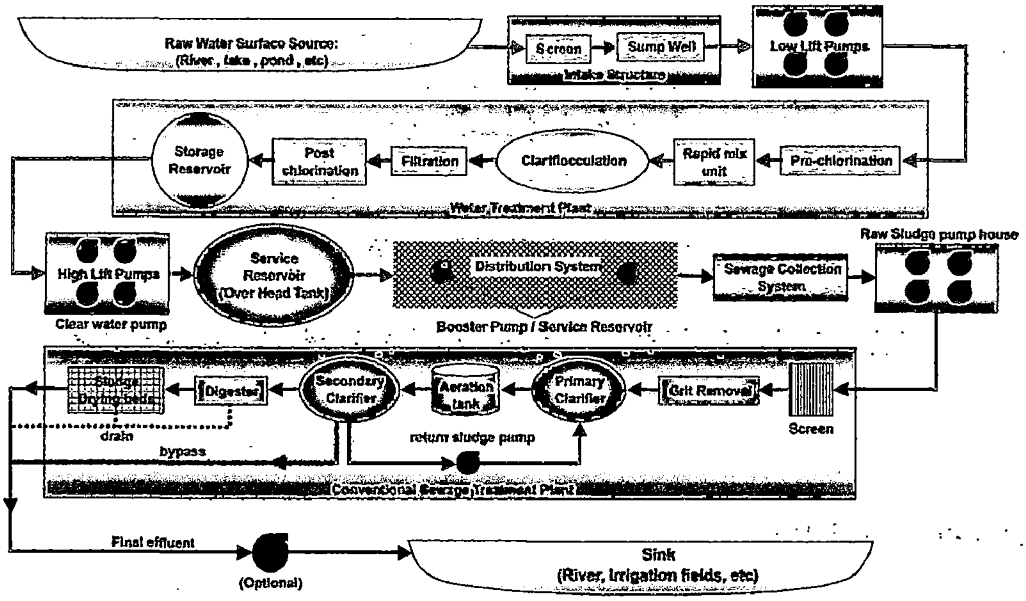


Fig. 2.1. Components of Typical Water Supply Scheme

As practiced in water treatment, disinfection refers to operations aimed at killing or rendering harmless the pathogenic microorganisms. The potential consequences of microbial contamination are such that its control must always be of paramount importance. Many water treatment schemes are, in effect, a multi-stage barrier system for the removal of microbial contamination. Even the cleanest of waters is disinfected to protect the public health from diseases caused by pathogens. So much so that the whole treatment sequence is sometimes regarded as conditioning the water for effective and reliable disinfection.

An effective disinfectant for drinking water supplies should satisfy the following criteria :

1. Be capable of destroying pathogens within available contact time.
2. Should be influenced less by the range of physical and chemical properties of water.
3. Should not form reaction by-products which render water toxic, impart colour and/or otherwise make it un-potable.
4. Should leave stable residual concentrations to deal with small possible recontamination.

5. Be detectable by easy and simple analytical techniques in the applicable concentration range.

Broadly, disinfection processes include use of physical agents, chemicals and radiations. Physical methods include thermal (boiling) and ultrasonic waves. In chemical methods, oxidizing chemicals, metals and strong acids and alkalis may be used. Oxidizing chemicals such as chlorine and its compounds, ozone, bromine, iodine, potassium, permanganate, etc. are commonly used. Among metal ions, silver, cooper, cobalt and nickel possess significant bactericidal properties. Out of these ions only silver can be used for disinfecting drinking water supplies and that too is relatively ineffective against viruses and amoebic cysts in acceptable contamination of silver. Addition of acids or bases resulting in the pH values below approximately 3 and above 11 creates toxicity that pathogens are not able to tolerate. Pathogens do not survive long in such waters because of increased ionic strength and osmotic pressure, which are suggested to be responsible for the destruction of cells. In radiation methods, Ultraviolet rays, Gamma rays and X rays, which possess the potential to kill the microbes, may be used for disinfection.

Physical and radiation methods of disinfection find limited usage for the mass bulk of supply to be treated in a water treatment plant. A limitation of these methods is their inability to leave any residue. Chemical disinfectants find the maximum usage all over the world. Amongst chemical agents, chlorine, and its compounds are used most widely. For post-disinfection, free chlorine, chlorine dioxide and chloramines and ozone are among the most commonly used disinfectants (WHO, 2000 and USEPA, 1999)[2].

The role of disinfectant in a water supply is generally classified into primary disinfection and residual maintenance or secondary disinfection. The primary disinfection takes care of the pathogens present in the water from the sources. Residual disinfection is practiced to protect against recontamination in water distribution system.

Among the commonly used disinfectants, chlorine and its product have the advantage of leaving residuals in water. Presence of free chlorine residual safeguards against recontamination of water in water distribution system. For example, an initial chlorine residual of 0.2 mg/l can protect against sewage contamination of 0.1% by volume (Sneed, 1980)[2]. Also, the residual disinfection practice makes possible the use of residual chlorine concentration as an indicator parameter. The reason being that no simple, inexpensive tests are available for detecting the presence of specific microbes causing waterborne diseases. The presently used total coli-form test is only a general indicator of faecal contamination and not really a true indicator of the presence of other organisms. Secondly, even the presumptive test for microbial presence takes very long. If no microbiological examination of water quality can be performed, presence of residual concentration of disinfectant is taken as a sign of absence of pathogens. Because of this inability to test routinely for the presence of specific microorganisms, residual disinfection is recommended to safeguard drinking water during distribution against external contamination and microbial re-growth.

In India, chlorination is the method of disinfection in all major urban water supplies. The presence of free residual chlorine requires lowest possible content of chlorine consuming contaminants in water. Thus, the Indian Manual (1999)[2] recommends that a minimum residual concentration of chlorine (0.2 mg/l) be maintained as a safeguard, even at the farthest nodes of the water distribution system. It is normally assumed that water quality is microbiologically safe if minimum residual chlorine concentration is present in water.

2.2. COMPONENTS OF WATER DISTRIBUTION NETWORK

The purpose of a water distribution network is to supply the system's users with the amount of water demanded and to supply this water with adequate pressure under various loading conditions. A loading condition is defined as a time pattern of demand. A municipal water supply system may be subject to a number of different loading conditions : fire demand at different nodes; peak daily demand; a series of pattern varying throughout a day; or a critical load when one or more pipes are broken. In order to insure that a design is adequate, a number of loading conditions, including critical conditions, must be considered. The ability to operate under a variety of load patterns is required of a reliable network.

Water distribution systems have three major components : pumping stations, distribution storage and distribution piping. These components may be farther divided into subcomponents, which in turn can be divided into sub-subcomponents. For example, the pumping station component consists of structural, electrical, piping and pumping subcomponents. The pumping unit can be divided farther into sub-subcomponents : pump, driver, controls, power transmission. The exact definition of components, subcomponents and sub-subcomponents depends on the level of detail of the required analysis and to a somewhat greater extent on the level of detail of available data. In fact, the concept of component-subcomponent-sub-subcomponents merely defines a hierarchy of building blocks used to construct the water distribution system. Figure 2.2 shows the hierarchical relationship of system, components, subcomponents and sub-subcomponents for a water distribution system.

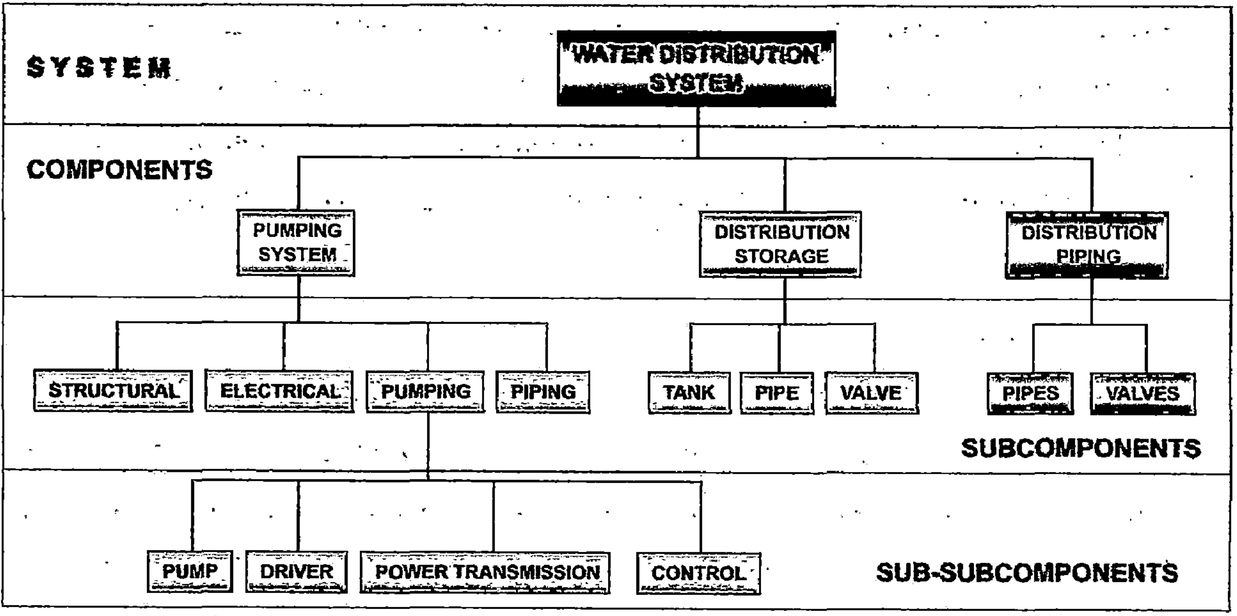


Fig. 2.2. Hierarchical Relationship of System for a Water Distribution System

(a) **Sub-subcomponents.** Sub-subcomponents represent the basic building blocks of systems. They are the smallest element for which failure and repair data are available. Individual sub-subcomponents may be common to a number of subcomponents within the water distribution system. Seven sub-subcomponents can be readily identified for analysis: pipes, valves, pumps, drivers, power transmission units, controls, and storage tanks. Data requirements, including time to failure and time to repair information can be found in published sources or in those cases where existing data is insufficient, a utility specific database can be developed.

(b) **Subcomponents.** Subcomponents represent the basic building blocks for components and are composed of one or more sub-subcomponents integrated into a common operational element. For example, the pumping unit subcomponent is composed of pipes, valves, pump, driver, power transmission, and control sub-subcomponents. These subcomponents can be used to evaluate the reliability of the urban water distribution systems: pumping units, pipe links, and storage tanks.

(c) **Components.** Components represent the largest functional element comprising the urban water supply scheme. Components are composed of one or more subcomponents.

A water distribution system operates of a system of independent components. The hydraulics of each component is relatively straightforward; however, these components depend directly upon each other and as a result affect one another's performance. The purpose of design and analysis is to determine how the systems perform hydraulically under various demand and operation conditions.

2.2.1. Pumps

Pumps are used to increase the energy in a water distribution system. There are many different types of pumps (positive-displacement pumps, kinetic pumps, turbine pumps, horizontal centrifugal pumps, vertical pumps and horizontal pumps). Centrifugal pumps are most commonly used in water distribution applications because of their low cost, simplicity and reliability in the range of flows and heads encountered (Mays, 2000). Centrifugal pumps are classified into three groups according to the manner in which the fluid moves through the pump :

2.2.1.1. Radial Flow Pump

The direction of flow for these machines is radial from the shaft of the machine (Figure 2.3). Flow enters the pump close to the shaft and the rotation of the impeller forces the flow outwards (centrifugal action) and into the volute at high velocity. The velocity is decreased and the head increased as flow expands in the volute. The large velocity change and inefficiencies in the expansion section reduces the overall efficiency of these units. For most applications an easily manufactured single stage unit will be employed. This type of unit is commonly used in water supply systems.

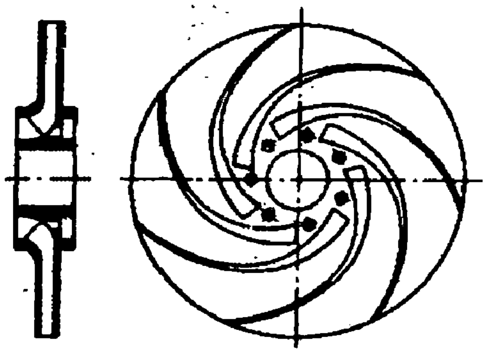
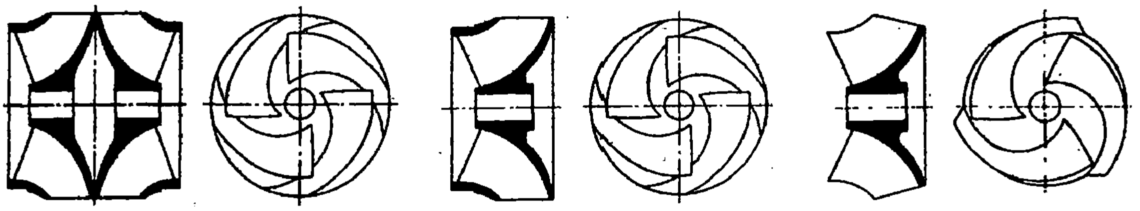


Fig. 2.3 Radial-flow Impellers

Basically, a centrifugal radial-flow pump has two main parts: (1) a rotating element (impeller and shaft) and (2) a stationary element (casing, stuffing box and bearings). Radial flow impellers are sometimes arranged so that water can enter the *eye* of the impeller from both sides. Such an impeller is called a *double-suction impeller*. It has the same effect as *two single-suction* impellers placed back to back and results in doubling the capacity without increasing impeller diameter.

2.2.1.2. Mixed Flow Pump

Mixed-flow centrifugal pumps use both centrifugal force and some lifting action to move water (Figure 2.4). Water is discharged both radial and axially into a volute-type casing. The process is a combination of processes occurring in volute and axial-flow types of pumps. Mixed-flow impellers are often used in deep-well turbine and submersible turbine pumps. As such mixed flow pumps are generally used where a large quantity of liquid is to be discharged to low heights. Some mixed flow impellers look like screw and are known as screw impellers. Mixed flow pumps borrow characteristics from both radial flow and axial flow pumps. As liquid flows through the impeller of a mixed flow pump, the impeller blades push the liquid out away from the pump shaft and the pump suction at an angle greater than 90°.



Mixed-flow closed, double entry   Mixed-flow impeller, closed   Mixed-flow impeller, open

Fig. 2.4 Types of Impeller (plan and side views)

2.2.1.3. Axial Flow Pump

The flow of liquid through the impeller is in the axial direction only (Figure 2.5). The direction of flow through these machines is parallel to the pump shaft. The action of the impeller is similar to a propeller, with relatively small changes in velocity through the pump. These machines designed to deliver very large quantities of liquid at relatively low heads and having high efficiencies. However, it is not justified to call axial flow pumps as centrifugal pumps, because there is hardly any centrifugal action in their operation.

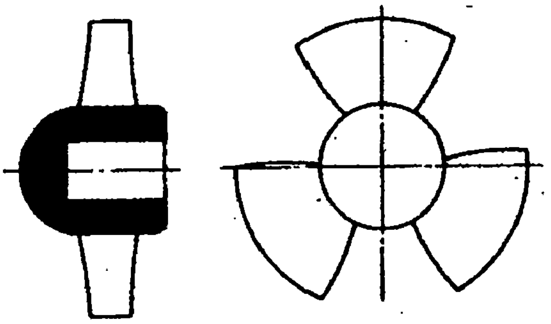


Fig. 2.5 Axial-flow Impeller

2.2.2. Water Storage

Distribution-system storage is needed to equalize pump discharge near an efficient operational point in spite of varying demands, to provide supply during outages of individual components, to provide water for fire fighting and to dampen out hydraulic transients.

Water use varies with time but most water treatment plants and their associated pump stations put out a fairly constant discharge. Storage tanks can equalize this difference between pump discharge and water consumption, thus preventing pumps from continually moving up and down their head characteristic curve as they would with no downstream storage. In additional, storage enable water-treatment-plant operators to operate their plants at a constant rate and reduce the changes in chemical feed rates.

Outages can occur in water distribution system due to power loss to pumping station and pipe breaks. Water kept in storage can supply customers until the system is made operational again.

Fires can place short-term demands on a distribution system in excess of the capacity of the pumping equipment. Without storage, a significant amount of excess pumping capacity would be required, especially at smaller pumping stations. Storage tank decrease the peak velocities and head losses in pipes carrying water from the source to the perimeter of the distribution system, thus resulting in reduced pipes sizes and costs for piping.

When velocities in pipes are changed quickly due to pump starts and stops, valve operation, or pipe breaks, hydraulic transient pressure fluctuation (water hammer) is created that can damage water distribution systems. Storage tank can dampen out the effect of these transients.

2.2.3. Pipes and Fittings

Water distribution piping can be of several types, including : ductile iron pipe (DIP), steel, polyvinyl chloride (PVC) pipe, asbestos cement (AC) pipe (ACP), reinforced concrete pressure pipe (RCPP) and others. The American Water Works Association (AWWA) publishes C-series standard that provide standards for pipe construction, installation and performance. The following are several factors that must be considered in the selection of both exposed and buried pipe and fittings (Bosserman et al., 1998)[51] :

- Properties of the fluid.
    - Corrosive or scale-forming properties.
    - Unusual characteristics, e.g., viscosity of sludge.
- Service conditions.
    - Pressure (including surges and transients).
    - Corrosive atmosphere for exposed piping.
    - Soil loads, bearing capacity and settlement, external loads and corrosion potential for buried piping.
- Availability.
    - Sizes.
    - Thickness.
    - Fittings.
- Properties of the pipe.
    - Strength (static and fatigue, especially for water hammer).
    - Ductility.
    - Corrosion resistance.
    - Fluid friction resistance of pipe or lining.

- Economics.
  - Required life.
  - Maintenance.
  - Cost.
  - Repairs.
  - Salvage value.

2.2.4. Appurtenances

In additional to the major components, pumps, tanks and pipes, there are numerous other appurtenances necessary to make a distribution system function properly.

2.2.4.1. Hydrants

Hydrants are most ubiquitous, visible water distribution system component. Hydrants are used primarily to provide water for fire fighting. They also used for system testing and water-main flushing.

The two main types of hydrants are wet barrel and dry barrel. Wet barrel hydrants can only be used in climates where freezing does not occur. Wet barrel hydrants stay full of water at all times. The operating mechanism for controlling hydrant flow is located in the outlet of the hydrant.

Dry barrel hydrants have their operating mechanism in the hydrant boot (i.e., the bottom of the hydrant). In this way the barrel stays dry and will not freeze, provided drains located in the base of the barrel allow the hydrant to drain.

Hydrants are controlled by turning the operating nut, which is usually a five sided nut; although other designs of operating nuts may be used to reduce theft of water. Hydrant outlet caps also have the same type of nut.

The ability of a fire hydrant to deliver water to a fire is usually expressed in terms of the flow it can deliver at 20 psi (138 kPa). To check the capacity of a hydrant at 20 psi, a hydrant flow test is conducted. To conduct a hydrant flow test, read the pressure at the hydrant (called the residual hydrant) during normal operating conditions, open up a nearby hydrant and measure the flow and read the pressure at the residual hydrant when the second hydrant is flowing (Mays, 1989).

2.2.4.2. Valves

Valves are very important for the proper functioning of water distribution system. The types of valves include :

- Isolation valves, used to shut down portions of a system, include :
    - ➢ Ball.
    - ➢ Butterfly.
    - ➢ Cone.
    - ➢ Eccentric plug.
    - ➢ Gate.
    - ➢ Plug.
- Check valves are directional control valves that allow flow of water to only one direction.
    - ➢ Swing check valves.
    - ➢ Counter-post-guided (or silent) check valves.
    - ➢ Double-door (or double-disc or double-leaf) check valves.
    - ➢ Foot valves.
    - ➢ Ball lift valves.
    - ➢ Tilting (or slanting) disc check valves.
- Control valves are used to regulate flow or pressure by operating partly open, creating high head losses and pressure differentials. These include pressure-reducing valves (PRV) and pressure-sustaining valves (PSV). PRVs are used to monitor (reduce) downstream pressures and PSVs are used to monitor pressures upstream of the valve.

- Air-release/Vacuum-breaker valves can be used for bleeding off air when a pipe is initially filled, although fire hydrants and customers taps can also aid in releasing air from the system.

2.2.4.3. Water Meters

Water meters are the devices which are used for measuring the quantity of water flowing under pressure through a pressure conduit. Mainly, there are two types of meters, viz.:

(a). The velocity meters or the inferential meters.
  - Rotary meter.
  - Turbine meter.
  - Venturi meter.

(b). The positive meters or the displacement meters.
  - Reciprocating type.
  - Oscillating type.
  - Disc type, etc.

2.3. SUMMARY

The available sources have to be assessed for their use under economical and feasible treatment processes. The required quality changes in the raw water are carried out by a number of physico-chemical processes at the treatment plant. Water treatment processes used in any specific instance must take into account the quality and nature of the water supply source. The intensity of treatment must depend on the degree of contamination of the source water. For contaminated water sources, multiple treatment units are required to give a high degree of protection and to reduce the reliance on any individual treatment step.

Disinfection is the final safeguard technique to prevent outbreaks of epidemics due to water borne diseases. Though disinfection action is possible by many methods, chemical disinfection is practiced the most. Among chemical disinfection agents, chlorine and its compounds take the lead.

After the water has been properly treated and made safe and wholesome, it has to be supplied to the consumers. The water has, therefore, to be taken from treatment plant to the roads and streets in the city, and finally to the individual houses. This function of carrying the water from treatment plant to the individual homes is accomplished through a well planned distribution system.

A distribution system may, therefore, consist of pipelines of various sizes for carrying the water to the consumers, valves for controlling the flow in the pipes, hydrants for providing connections with the water mains for releasing water during fires, meter for measuring discharges, pumps for lifting and forcing the water into the distribution pipes and storage for storing the treated water to be fed into the distribution pipes. Further, the water may be supplied to the public either continuously for all the 24 hours of the day, or it may be supplied intermittently during certain fixed hours of the day.

CHAPTER 3

HYDRAULIC AND WATER QUALITY MODELLING USING EPANET

3.1. INTRODUCTION

The role of water distribution network in drinking water supply schemes is to transport water from treatment plant to the consumers. Conventionally, water distribution networks are designed to provide required discharge with adequate pressure. However, quality of finished water has been found to undergo many a change during its transit from the treatment plant to the consumer end.

With the growing comprehension of relationship between disease and drinking water quality, the regulations are becoming wider and stringent. To fulfil the water quality standard, generally the focus is on source protection and treating drinking water to higher levels. Modern technologies at the treatment plant produce a high-quality product. Nevertheless, distribution systems are still being operated only for water delivery with less attention paid to maintaining quality. An important question is what will happen to this water as it travels through a water distribution network, designed perhaps decades ago. Will this high quality water develop objectionable tastes, colours and odours; lose its disinfectant residual; support microbiological growth, get contaminated due to cross connections with sewers and most important, will consumers have confidence this water?

Recent developments in computer software now provide a capability to build representative models, which can simulate hydraulic characteristics and concentration of water quality parameters under steady and dynamic flow conditions.

The hydraulic and water quality models are generally used for the following applications :

1. To analyze the network with multi demand categories at nodes.
2. To analyze the network with any shape of storage tanks and various types of valves.
3. Computes friction head loss.
4. Computes pumping energy and cost.
5. Calculation of water age throughout the water distribution network to identify the areas of old and young water and the effects of system changes.
6. Prediction of various parameters concentrations due to blending of water from different sources or reactions and/or residence in the water distribution network.
7. Tracking of movement, mixing and dispersion of potentially harmful substances and the design of operational solutions in the event of contamination problems.
8. Prediction of residual chlorine decay in the water distribution network.
9. Location and operation of chlorination units to meet disinfectant and residual maintenance requirements.

Computer modeling used, not only to analyze the flow and pressure, but also to track the propagation of water borne substances in the water distribution network. The basic principles and equations used in the hydraulic and water quality simulation have been described in detail. Features of a popular hydraulic and water quality model, EPANET 2.0 (Rossman, 2000) have been described. An illustration example is presented for hydraulic and water quality simulation of a water distribution network using EPANET.

3.2. HYDRAULIC ANALYSIS

The basic equations used in hydraulic analysis of closed conduit pressure flow are continuity equation, energy equation and loop equation.

Analysis of Flow

The first principle in dealing with pipe flows is the continuity of matter. According to the principle of continuity for an incompressible fluid, the sum of volumes of water entering a junction (ΣV_{in}) equals the flow leaving the junction (ΣV_{out}) over a given time, i.e.,

$$\sum V_{in} = \sum V_{out} \tag{3.1}$$

Further, according to the principle of conservation of energy, the total energy of flow at two cross-sections will be the same if there is no energy loss. The total energy in terms of the head of water is expressed by the Bernoulli equation. For flow between two cross-sections 1 and 2, we have

$$z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_{L,1-2} \tag{3.2}$$

where z_1 is the elevation head, P_1 is the pressure head, γ is the unit weight of water, V_1 is the velocity of flow; subscript 1 denotes that the variables refer to cross-section 1; and $h_{L1\text{-}2}$ denotes head loss between cross-sections 1 and 2. The loss of energy in a pipe network takes place due to the roughness of pipes, turbulence, and viscous stress. Some energy is also lost in contractions, expansions, bends, joints, and valves. This loss is termed as minor loss. Generally, the minor head loss is proportional to $(V^2/2g)$.

During flow in pipelines, a part of energy contained in the fluid gets into a non-recoverable form of energy, which thus leads to frictional head losses. There are several equations available in the literature , which can be used to evaluate frictional head loss, but the most fundamentally sound method for computing such head losses is by Darcy Weisbach equation, given by:

$$h_L = f\frac{L}{D}\frac{V^2}{2g} = KQ^2 \tag{3.3}$$

where L is its length (m), and f is the Darcy-Weisbach friction factor which depends on relative roughness (k_s/D) and Reynolds number (R_e). Here, k_s is the equivalent sand roughness which is the resistance characteristics produced by a pipe of the same diameter, internally coated with sand particles having diameter k_s. The Reynolds number is the ratio of inertial forces to viscous forces = VD/ν, ν being the kinematics viscosity.

Table 3.1. Summary of Friction Factor Equations for Darcy Weisbach Equation

Type of Flow	Equations giving 'f'	Range of Application
Laminar	$f = 64/R_e$	$R_e < 2100$
Hydraulically Smooth or Turbulent Smooth	$f = 0.316/R_e^{0.25}$ $\frac{1}{\sqrt{f}} = 2\log_{10}(R_e\sqrt{f}) - 0.8$	$4000 < R_e < 10^5$ $R_e > 4000$
Transition between Hydraulically smooth and wholly rough	$\frac{1}{\sqrt{f}} = 1.14 - 2\log_{10}(\frac{k_s}{D} + \frac{93.5}{R_e\sqrt{f}})$	$R_e > 4000$
Hydraulically Rough or Turbulent Rough	$\frac{1}{\sqrt{f}} = 1.14 - 2\log_{10}(\frac{k_s}{D})$	$R_e > 4000$

Besides the Darcy Weisbach equation, certain empirical equations (as Hazen Williams equation) are often used for determining frictional head losses in a closed conduit.

Hazen-Williams equation:

The most widely used empirical equation is the Hazen-Williams equation, which can be written as :

$$V = 0.849\, C\, R^{0.63}\, S_f^{0.54} \qquad (3.4)$$

where V is the flow velocity in m/s, R is the hydraulics radius (m), S_f is the friction slope (h_L / L), and C is the Hazen-Williams roughness coefficient which depends upon the pipe properties. The hydraulic radius is the ratio of wetted cross section area and wetted perimeter. For a pipe, $R = A/P = \pi r^2/2\pi r = r/2$, where r is the radius of the pipe. The head loss due to friction (in meters) can be computed by:

$$h_L = \frac{10.7L}{C_{HW}^{1.852} D^{4.87}} Q^{1.852} = KQ^{1.85} \qquad (3.5)$$

where D is the diameter of pipe (m) and K is the pipe coefficient.

Table 3.2. Values of Hazen Williams Coefficient for common Pipe Materials

Type of Pipe	Hazen Williams Coefficient
PVC pipe	150
Very Smooth Pipe	140
New cast Iron or Welded Steel	130
Wood , Concrete	120
Clay , New Riveted Steel	110
Old Cast Iron , Brick	100
Badly Corroded Cast Iron or Steel	80

Comparison of Hazen Williams Equation with Darcy Weisbach Equation

The comparison of Hazen Williams equation with Darcy Weisbach equation can best be done by manipulating the Hazen Williams equation in the form of Darcy Weisbach equation, and then examining the relationship given by that equation in defining friction factor 'f'. So, Hazen Williams equation when manipulated into the form of Darcy Weisbach Equation would result in :

$$f = \left(\frac{1018.4}{C^{1.85} D^{0.018} R_e^{0.148}} \right) \tag{3.6}$$

provided, Kinematic viscosity = 1.31 * 10^{-6} m^2/s at 15.6 °C and g = 9.81 m/s^2.

Minor Head Losses

Minor head losses (also called local losses) are caused by the added turbulence that occurs at bends and fittings. The importance of including such losses depends on the layout of the network and the degree of accuracy required. They can be accounted for by assigning the pipe a minor loss coefficient. The minor head loss becomes the product of this coefficient and the velocity head of the pipe, i.e.,

$$h_L = k\frac{V^2}{2g} \tag{3.7}$$

where k = minor loss coefficient, v = flow velocity (length/time), and g = acceleration of gravity (length/time). Table 3.3 provides minor loss coefficients for several types of fittings.

Table 3.3. Minor Loss Coefficients for Selected Fittings

Fitting	Loss Coefficient
Globe valve, fully open	10.0
Angle valve, fully open	5.0
Swing check valve, fully open	2.5
Gate valve, fully open	0.2
Short-radius elbow	0.9
Medium-radius elbow	0.8
Long-radius elbow	0.6
45 degree elbow	0.4
Closed return bend	2.2
Standard tee-flow through run	0.6
Standard tee-flow through branch	1.8
Square entrance	0.5
Exit	1.0

Analytical Relation for Compound Pipes

The hydraulic problem in connection with pipe networks consists of solving for the distribution of flow and head loss in the individual elements for a given total discharge or for a given total head loss. For each element, there are two unknowns, the discharge and head loss, and for the system as a whole one unknown, the head loss or the discharge. Hence the number of unknown equals twice the number of elements plus one.

The equations required for the solution of the unknowns are of three types and arise from three laws as follows :

1. The head loss varies as some power of the discharge, equation (3.5).
2. The algebraic sum of the discharge rates toward any junction point is zero.
3. The total head loss between any two points in the system is the algebraic sum of the head loss of all the elements along any route between the points, and the total head loss is the same by all routes.

Equivalent Pipes

In solving large net works of pipes, it becomes sometimes more convenient to first replace the different small loops by single 'Equivalent Pipes' having the same carrying capacity and causing the same loss of head. This can be obtained by using the two elementary principles in hydraulics viz.,

1. The head of loss due to the flow of a given quantity of water through pipes series is additive.
2. The quantity of water flowing through pipe in parallel must be such that loss of head through each line is the same.

Extended Period Hydraulic Simulation

Various methods of extended period hydraulic simulation of water distribution networks were dealt of these are static node head analysis, dynamic node head analysis, static node flow analysis and dynamic node flow analysis. Some of the commonly used static node head analysis are presented here.

Hardy Cross method **(Cross, 1936)** is one of the first and probably the most widely used method of analysis. It is based upon successive approximation corrected rates of flow until the head loss between points of divergent and convergent flow is balanced, i.e., it makes correction to initial assumed values by using a first order expansion of the energy equation in terms of correction factor for flow rate in each loop. The process is of course repetitive and is dependent on the initial guess, which must be reasonable good if an answer is to obtain rapidly. The method solves one equation at a time before proceeding to the next equation during each iteration instead of solving all equations simultaneously. However the method is suitable for hand calculation and also number of digital program has been developed for analysis.

Basic steps of this method are follows :

(1) Assume any distribution of discharge.

(2) Compute the head loss in each element by means of equation (3.5).

(3) With due attention to sign, compute the total head loss around each elementary closed circuit : $\sum h = \sum KQ^x$

(4) Compute also for each elementary circuit without reference to sign the sum : $\sum xKQ_1^{(x-1)}$

(5) To balance the head in each circuit (so that $\sum KQ^x = 0$), set up a counterbalancing flow equal by means of $\Delta Q = \frac{\sum KQ_1^x}{\sum xKQ_1^{(x-1)}} = \frac{\sum h}{x\sum \frac{h}{Q}}$.

(6) Compute the revised flows, and repeat the process until the desired accuracy is obtained.

Newton-Raphson method **(Martin and Peters, 1963)** is the most widely used method because it exhibits quadratic convergence, which means that each subsequent error reduction to the square of the previous error. In general, a solution to the equation $f(x) = 0$ is obtained by iterative formula i.e.

$$x^{m+1} = x^m - \frac{f(x^m)}{f'(x^m)} \qquad (3.8)$$

Newton-Raphson method may be used to solve any of these sets of equations i.e. the equations considering : (1) The flow rate in each pipe as unknown; (2) the head at each junction as unknown; (3) the corrective flow rate around each loop as unknown. Newton-Raphson method required an initial guess to the solution and it's the best method to use for larger system of equations.

Newton-Raphson method for a system of simultaneous equations

The iterative Newton-Raphson formula for a system is :

$$\bar{x}^{(m+1)} = \bar{x}^{(m)} - D^{-1}\bar{F}(x^{(m)}) \qquad (3.9)$$

The unknown vectors $\vec{x}$ and $\vec{F}$ replace the single variable 'x' and function 'F' and the inverse of the Jacobian matrix D^{-1} replaces $1/dF/dx$ in Newton-Raphson formula for solving single equation. For solving equations with heads as unknowns (head equations), the vector $\vec{x}$ becomes vector $\vec{H}$ and for solving equations containing corrective loop flow rates, the vector $\vec{x}$ becomes the vector $\vec{H}$ and if solving the equations corrective loop flow rates it becomes Q. The individual elements for H and Q are :

$$\vec{H} = \begin{vmatrix} H_1 \\ H_2 \\ \dots \\ H_n \end{vmatrix} \text{with known H omitted from vector or } \Delta Q = \begin{vmatrix} \Delta Q_1 \\ \Delta Q_2 \\ \dots \\ \Delta Q_n \end{vmatrix}$$

The Jacobian matrix 'D' consists of derivative elements. For head equations, the Jacobian matrix 'D' is :

$$D = \begin{bmatrix} \frac{\partial F_1}{\partial H_1} & \frac{\partial F_1}{\partial H_2} & \dots & \frac{\partial F_1}{\partial H_j} \\ \frac{\partial F_2}{\partial H_1} & \frac{\partial F_2}{\partial H_2} & \dots & \frac{\partial F_2}{\partial H_j} \\ & & \dots & \\ \frac{\partial F_j}{\partial H_1} & \frac{\partial F_j}{\partial H_2} & \dots & \frac{\partial F_j}{\partial H_j} \end{bmatrix} \tag{3.10}$$

In the above matrix, the rows and column corresponding to the known head are omitted. The last term $D^{-1}F$ implies the inverse of Jacobian matrix 'D'. However, in application, inverse is not done, rather solution vector 'z' of linear system Dz = F is subtracted from previous iterative vector of unknowns. Selecting the 'H' equations in the following notation, the Newton-Raphson iterative formula in practice becomes :

$$\vec{H}^{m+1} = \vec{H}^{m} - \vec{z}^{m} \tag{3.11}$$

Linear Theory **(Wood and Charles, 1972)** is useful for network analysis and works on the principle "balancing heads by correcting assumed flow". In a network of n_p pipes and j junctions and l loops, it has been shown that the following identity holds :

$$N_p = j + l - 1 \tag{3.12}$$

This is true for network with all closed loops, for open tree-type network, or combination of both types. It is possible to write $j - 1$ linear continuity equations for all but one of the junction in the network stating that discharge into the junction equals the discharge out of the junction :

$$Q_{in} = Q_{out} \tag{3.13}$$

in which Q = discharge.

In addition there are l non-linear energy equations (one for each loop) of the form :

$$\Sigma h_L = 0 \tag{3.14}$$

where h_L represents the head loss in the pipe contained in that loop and is a function of the discharge, Q. From the above two equation, n_p simultaneous equations are obtained in terms of the discharge in each pipe. Theoretically, these equations could be solved for the discharge.

It is proposed here in to transform the loop equation into linear equation by approximating the head loss by :

$$\Sigma h_{Li} = K_i\, Q_i^x = K_i\, Q_{io}^{x-1}\, Q_i = K_i^{'}\, Q_i \tag{3.15}$$

in which Q_{io} = the approximate discharge in line i. Of course, when Q_{io} approaches the actual discharge, Q_i, equation (3.15) becomes an exact expression of the head loss. Using value for approximate discharge to compute the modified pipe line constant, $K_i^{'}$, the loop equation can be expressed as linear equation, which when combined with the continuity equation yields n_p linear simultaneous network equation which can be readily solved for the discharge in each line.

The computed values for discharge can be then used to compute new values for the modified pipeline constant $K_i^{'}$, which are used to obtain a new set of n_p simultaneous equation, which can be solved for improved values for line discharge. This process can be continued until the discharge obtained from two successive sets of calculation do not differ significantly.

The convergence of the solution depends on the initial estimate of flow rate. For this technique, it is not necessary to estimate flow rates. Instead, reasonably accurate initial flow rate can be easily calculated by assuming that modified pipeline constant is independent of flow rate and, as first approximation is given by

$$K_i' = K_i \tag{3.16}$$

In this method, it was observed that the average of two successive trials gave a result very close to the final value of flow rate. It was used to compute the best value of the discharge for that trial and modified pipeline constant, K_i' which is employed for the next trial. This is expressed as

$$Q_{io} = \frac{Q_{i-1} + Q_{i-2}}{2} \tag{3.17}$$

where Q_{i-1} = the flow rate obtained from the previous trial for line i and Q_{i-2} = the flow rate obtained for the trial previous to that. In this method to solve n_p simultaneous linear equation any of the methods, i.e. Gaussian-ellimination, Gauss-Jordan and L-U decomposition may be used.

The step to analyse the water distribution network, is as follows :

(1) Calculate K_i values for each pipeline.

(2) Assume that the modified pipeline constant $K_i' = K_i$ for each line and solving the simultaneous linear equations.

(3) Calculate the modified pipeline constant K_i' from discharge obtained in step 2 and again solve for simultaneous equation.

(4) Compute the average of two prior sets of calculated flow rates and using this value find out new K_i' value.

(5) Using step 4 solve simultaneous equation.

Repeat step 4 and 5 until the desired accuracy is reached.

Gradient Algorithm method (Todini and Pilati, 1987)[64] The proposed in which assuming a pipe network with *N* junction nodes and *NF* fixed grade nodes (tanks and reservoirs). Let the flow-head loss relation in a pipe between nodes *i* and *j* be given as:

$$H_i - H_j = h_{ij} = KQ_{ij}^x + kQ_{ij}^2 \qquad (3.18)$$

where H = nodal head, h = head loss, K = resistance coefficient, Q = flow rate, x = flow exponent, and k = minor loss coefficient. The value of the resistance coefficient will depend on which friction head loss formula is being used (see below). For pumps, the head loss (negative of the head gain) can be represented by a power law of the form

$$h_{ij} = \omega^2 \left(h_o - K(Q_{ij} / \omega)^x\right) \qquad (3.19)$$

where h_0 is the shutoff head for the pump, ω is a relative speed setting, and K and x are the pump curve coefficients. The second set of equations that must be satisfied is flow continuity around all nodes:

$$\sum_j \Sigma Q_{ij} - D_i = 0 \qquad \text{for } i = 1,\dots \text{N} \qquad (3.20)$$

where D_i is the flow demand at node i and by convention, flow into a node is positive. For a set of known heads at the fixed grade nodes, we seek a solution for all heads H_i and flows Q_{ij} that satisfy equations (3.18) and (3.20).

The Gradient solution method begins with an initial estimate of flows in each pipe that may not necessarily satisfy flow continuity. At each iteration of the method, new nodal heads are found by solving the matrix equation:

$$\mathbf{AH} = \mathbf{F} \qquad (3.21)$$

where **A** = an (NxN) Jacobian matrix, **H** = an (Nx1) vector of unknown nodal heads, and F = an (Nx1) vector of right hand side terms.

The diagonal elements of the Jacobian matrix are:

$$A_{ij} = \sum_j P_{ij} \qquad (3.22)$$

while the non-zero, off-diagonal terms are:

$$A_{ij} = -P_{ij} \tag{3.23}$$

where p_{ij} is the inverse derivative of the head loss in the link between nodes i and j with respect to flow. For pipes,

$$P_{ij} = \frac{1}{xK\left|Q_{ij}\right|^{x-1} + 2k\left|Q_{ij}\right|} \tag{3.24}$$

while for pumps

$$P_{ij} = \frac{1}{x\omega^2 K\,(Q_{ij}/\omega)^{x-1}} \tag{3.25}$$

Each right hand side term consists of the net flow imbalance at a node plus a flow correction factor :

$$F_i = \left(\sum_j Q_{ij} - D_i\right) + \sum_j Y_{ij} + \sum_f P_{ij} H_f \tag{3.26}$$

where the last term applies to any links connecting node i to a fixed grade node f and the flow correction factor y_{ij} is :

$$Y_{ij} = P\left(K|Q|^x + k|Q|^2\right)\mathrm{sgn}(Q_{ij}) \tag{3.27}$$

For pipes and

$$Y_{ij} = -P_{ij}\omega^2\left(h_o - \left(KQ_{ij}/\omega\right)^x\right) \tag{3.28}$$

For pumps, where sgn(x) is 1 if $x > 0$ and -1 otherwise. (Q_{ij} is always positive for pumps.)

After new heads are computed by solving equation (3.21), new flows are found from:

$$Q_{ij} = Q_{ij} - \left(Y_{ij} - P_{ij}\left(H_i - H_j\right)\right) \tag{3.29}$$

If the sum of absolute flow changes relative to the total flow in all links is larger than some tolerance (e.g., 0.001), then equations (3.21) and (3.29) are solved once again.

The flow update equation (3.29) always results in flow continuity around each node after the first iteration.

Because of Todini and Pilati's approach is simpler, it was chosen for use in EPANET. EPANET implements Gradient method using the following steps:

1. The linear system of equation (3.21) is solved using a sparse matrix method based on node re-ordering (George and Liu, 1981). After reordering the nodes to minimize the amount of fill-in for matrix A, a symbolic factorization is carried out so that only the non-zero elements of A need be stored and operated on in memory. For extended period simulation this re-ordering and factorization is only carried out once at the start of the analysis.

2. For the very first iteration, the flow in a pipe is chosen equal to the flow corresponding to a velocity of 1 m/sec, while the flow through a pump equals the design flow specified for the pump.

3. The resistance coefficient for a pipe (r) is computed as described in previous chapter. For the Darcy-Weisbach head loss equation, the friction factor f is computed by different equations depending on the flow's Reynolds Number (Re):

   Hagen – Poiseuille formula for Re < 2,000 (Bhave, 1991) :

   $$f = \frac{64}{\mathrm{Re}}$$

   Swamee and Jain approximation to the Colebrook - White equation for Re > 4,000 (Bhave, 1991) :

   $$f = \frac{0.25}{\left[Ln\left(\frac{\varepsilon}{3.7d} + \frac{5.74}{\mathrm{Re}^{0.9}}\right)\right]^2}$$

Cubic Interpolation From Moody Diagram for 2,000 < Re < 4,000 (Dunlop, 1991):

$$f = (X_1 + R(X_2 + R(X_3 + X_4)))$$

$$R = \frac{\text{Re}}{2000}$$

$$X_1 = 7FA - FB$$

$$X_2 = 0.128 - 17FA + 2.5FB$$

$$X_3 = -0.128 + 13FA - 2FB$$

$$X_4 = R(0.032 - 3FA + 0.5FB)$$

$$FA = (Y_3)^{-2}$$

$$FB = FA\left(2 - \frac{0.00514215}{(Y_2)(Y_3)}\right)$$

$$Y_2 = \frac{\varepsilon}{3.7\text{d}} + \frac{5.74}{\text{Re}^{0.9}}$$

$$Y_3 = -0.86859Ln\left(\frac{\varepsilon}{3.7d} + \frac{5.74}{4000^{0.9}}\right)$$

where ε = pipe roughness and d = pipe diameter.

4. The minor loss coefficient based on velocity head (k) is converted to one based on flow (m) with the following relation:

$$m = \frac{0.0251k}{d^4}$$

5. Emitters at junctions are modeled as a fictitious pipe between the junction and a fictitious reservoir. The pipe's head loss parameters are $n = (1/\gamma)$, $r = (1/C)^n$, and $m = 0$ where C is the emitter's discharge coefficient and γ is its pressure exponent. The head at the fictitious reservoir is the elevation of the junction. The computed flow through the fictitious pipe becomes the flow associated with the emitter.

6. Open valves are assigned an r-value by assuming the open valve acts as a smooth pipe (f = 0.02) whose length is twice the valve diameter. Closed links are assumed to obey a linear head loss relation with a large resistance factor, i.e., $h = 10^8 Q$, so that $p = 10^{-8}$ and $y = Q$. For links where $(r+m)Q < 10^{-7}$, $p = 10^7$ and $y = Q/n$.

7. Status checks on pumps, check valves (CVs), flow control valves, and pipes connected to full/empty tanks are made after every other iteration, up until the 10th iteration. After this, status checks are made only after convergence is achieved. Status checks on pressure control valves (PRVs and PSVs) are made after each iteration.

8. During status checks, pumps are closed if the head gain is greater than the shutoff head (to prevent reverse flow). Similarly, check valves are closed if the head loss through them is negative (see below). When these conditions are not present, the link is re-opened. A similar status check is made for links connected to empty/full tanks. Such links are closed if the difference in head across the link would cause an empty tank to drain or a full tank to fill. They are reopened at the next status check if such conditions no longer hold.

9. Simply checking if $h < 0$ to determine if a check valve should be closed or open was found to cause cycling between these two states in some networks due to limits on numerical precision. The following procedure was devised to provide a more robust test of the status of a check valve (CV):

   ```
   if $|h| > H_{tol}$ then
       if $h < -H_{tol}$   then   status = CLOSED
       if $Q < -Q_{tol}$   then   status = CLOSED
                           else   status = OPEN
   else
       if $Q < -Q_{tol}$   then   status = CLOSED
                           else   status = unchanged
   ```

   where $H_{tol} = 0.0005$ m and $Q_{tol} = 0.001$ m^3/sec.

10. If the status check closes an open pump, pipe, or CV, its flow is set to 10^{-6} m^3/sec. If a pump is re-opened, its flow is computed by applying the current head gain to its characteristic curve. If a pipe or CV is reopened, its flow is determined by solving equation (3.18) for Q under the current head loss h, ignoring any minor losses.

11. Matrix coefficients for pressure breaker valves (PBVs) are set to the following : $p = 10^8$ and $y = 10^8 H_{set}$, where Hset is the pressure drop setting for the valve. Throttle control valves (TCVs) are treated as pipes with r as described in item 6 above and m taken as the converted value of the valve setting (see item 4 above).

12. Matrix coefficients for pressure reducing, pressure sustaining, and flow control valves (PRVs, PSVs, and FCVs) are computed after all other links have been analyzed. Status checks on PRVs and PSVs are made as described in item 7 above. These valves can either be completely open, completely closed, or active at their pressure or flow setting.

13. The logic used to test the status of a PRV is as follows:

```
If current status = ACTIVE then
    if $Q < -Q_{tol}$                          then new status = CLOSED
    if $H_i < H_{set} + H_{ml} - H_{tol}$      then new status = OPEN
                                               else new status = ACTIVE

If current status = OPEN then
    if $Q < -Q_{tol}$                          then new status = CLOSED
    if $H_i > H_{set} + H_{ml} + H_{tol}$      then new status = ACTIVE
                                               else new status = OPEN

If current status = CLOSED then
    if $H_i > H_j + H_{tol}$
    and $H_i < H_{set} - H_{tol}$              then new status = OPEN
    if $H_i > H_j + H_{tol}$
```

and $H_j < H_{set} - H_{tol}$ then new status = ACTIVE

else new status = CLOSED

where Q is the current flow through the valve, H_i is its upstream head, H_j is its downstream head, Hset is its pressure setting converted to head, H_{ml} is the minor loss when the valve is open (= mQ^2), and H_{tol} and Q_{tol} are the same values used for check valves in item 9 above. A similar set of tests is used for PSVs, except that when testing against H_{set}, the i and j subscripts are switched as are the > and < operators.

14. Flow through an active PRV is maintained to force continuity at its downstream node while flow through a PSV does the same at its upstream node. For an active PRV from node i to j:

$$p_{ij} = 0$$
$$F_j = F_j + 10^8 H_{set}$$
$$A_{jj} = A_{jj} + 10^8$$

This forces the head at the downstream node to be at the valve setting H_{set}. An equivalent assignment of coefficients is made for an active PSV except the subscript for F and A is the upstream node i. Coefficients for open/closed PRVs and PSVs are handled in the same way as for pipes.

15. For an active FCV from node i to j with flow setting Q_{set}, Q_{set} is added to the flow leaving node i and entering node j, and is subtracted from F_i and added to F_j. If the head at node i is less than that at node j, then the valve cannot deliver the flow and it is treated as an open pipe.

16. After initial convergence is achieved (flow convergence plus no change in status for PRVs and PSVs), another status check on pumps, CVs, FCVs, and links to tanks is made. Also, the status of links controlled by pressure switches (e.g., a pump controlled by the pressure at a junction node) is checked. If any status change occurs, the iterations must continue for at least two more iterations (i.e., a

convergence check is skipped on the very next iteration). Otherwise, a final solution has been obtained.

17: For extended period simulation (EPS), the following procedure is implemented :

a. After a solution is found for the current time period, the time step for the next solution is the minimum of:
   - The time until a new demand period begins,
   - The shortest time for a tank to fill or drain,
   - The shortest time until a tank level reaches a point that triggers a change in status for some link (e.g., opens or closes a pump) as stipulated in a simple control,
   - The next time until a simple timer control on a link kicks in,
   - The next time at which a rule-based control causes a status change somewhere in the network.

In computing the times based on tank levels, the latter are assumed to change in a linear fashion based on the current flow solution. The activation time of rule-based controls is computed as follows:

- Starting at the current time, rules are evaluated at a rule time step. Its default value is 1/10 of the normal hydraulic time step (e.g., if hydraulics are updated every hour, then rules are evaluated every 6 minutes).
- Over this rule time step, clock time is updated, as are the water levels in storage tanks (based on the last set of pipe flows computed).
- If a rule's conditions are satisfied, then its actions are added to a list. If an action conflicts with one for the same link already on the list then the action from the rule with the higher priority stays on the list and the other is removed. If the priorities are the same then the original action stays on the list.
- After all rules are evaluated, if the list is not empty then the new actions are taken. If this causes the status of one or more links to change then a new hydraulic solution is computed and the process begins anew.

   - If no status changes were called for, the action list is cleared and the next rule time step is taken unless the normal hydraulic time step has elapsed.

b. Time is advanced by the computed time step, new demands are found, tank levels are adjusted based on the current flow solution, and link control rules are checked to determine which links change status.

c. A new set of iterations with equations (3.21) and (3.29) are begun at the current set of flows.

3.3. WATER QUALITY ANALYSIS

The governing equations for water quality solver are based on the principles of conservation of mass coupled with reaction kinetics.

Advective Transport in Pipes

A dissolved substance will travel down the length of a pipe with the same average velocity as the carrier fluid while at the same time reacting (either growing or decaying) at some given rate. Longitudinal dispersion is usually not an important transport mechanism under most operating conditions. This means there is no intermixing of mass between adjacent parcels of water traveling down a pipe. Advective transport within a pipe is represented with the following equation :

$$\frac{\partial C_i}{\partial t} = -u_i \frac{\partial C_i}{\partial x} + r(C_i) \tag{3.30}$$

where C_i = concentration (mass/volume) in pipe i as a function of distance x and time t, u_i = flow velocity (length/time) in pipe i, and r = rate of reaction (mass/volume/time) as a function of concentration.

Mixing at Pipe Junctions

At junctions receiving inflow from two or more pipes, the mixing of fluid is taken to be complete and instantaneous. Thus the concentration of a substance in water leaving the junction is simply the flow-weighted sum of the concentrations from the inflowing pipes. For a specific node k one can write:

$$C_{i|x=0} = \frac{\sum_{j \in I_k} Q_j C_{j|x=L_j} + Q_{k,ext} C_{k,ext}}{\sum_{j \in I_k} Q_j + Q_{k,ext}} \qquad (3.31)$$

where i = link with flow leaving node k, I_k = set of links with flow into k, L_j = length of link j, Q_j = flow (volume/time) in link j, $Q_{k,ext}$ = external source flow entering the network at node k, and $C_{k,ext}$ = concentration of the external flow entering at node k. The notation $Ci|x=0$ represents the concentration at the start of link i, while $C_{i|x=L}$ is the concentration at the end of the link.

Mixing in Storage Facilities

It is convenient to assume that the contents of storage facilities (tanks and reservoirs) are completely mixed. This is a reasonable assumption for many tanks operating under fill-and-draw conditions providing that sufficient momentum flux is imparted to the inflow (Rossman and Grayman, 1999). Under completely mixed conditions the concentration throughout the tank is a blend of the current contents and that of any entering water. At the same time, the internal concentration could be changing due to reactions. The following equation expresses these phenomena :

$$\frac{\partial(V_s C_s)}{\partial t} = \sum_{i \in I_s} Q_i C_{i|x=L_i} - \sum_{j \in O_s} Q_j C_s + r(C_s) \qquad (3.32)$$

where Vs = volume in storage at time t, C_s = concentration within the storage facility, I_s = set of links providing flow into the facility, and O_s = set of links withdrawing flow from the facility.

Bulk Flow Reactions

While a substance moves down a pipe or resides in storage it can undergo reaction with constituents in the water column. The rate of reaction can generally be described as a power function of concentration:

$$r = K_b C^n \tag{3.33}$$

where K_b = a reaction constant and n = the reaction order. When a limiting concentration exists on the ultimate growth or loss of a substance then the rate expression becomes

$r = K_b(C_L - C)C^{(n-1)}$ for $n>0$, $K_b>0$
$r = K_b(C - C_L)C^{(n-1)}$ for $n>0$, $K_b<0$

where C_L = the limiting concentration.

Some examples of different reaction rate expressions are :

- *Simple First-Order Decay ($C_L = 0$, $K_b < 0$, $n = 1$)*

  $r = K_b C$

  The decay of many substances, such as chlorine, can be modeled adequately as a simple first-order reaction.

- *First-Order Saturation Growth ($C_L > 0$, $K_b > 0$, $n = 1$) :*

  $r = K_b(C_L - C)$

  This model can be applied to the growth of disinfections by-products, such as trihalomethanes, where the ultimate formation of by-product (C_L) is limited by the amount of reactive precursor present.

- *Two-Component, Second Order Decay ($C_L \neq 0$, $K_b < 0$, $n = 2$) :*

  $r = K_b C(C - C_L)$

  This model assumes that substance A reacts with substance B in some unknown ratio to produce a product P. The rate of disappearance of A is proportional to the product of A and B remaining. C_L can be either positive or negative, depending on whether either component A or B is in excess, respectively. Clark (1998) has had success in applying this model to chlorine decay data that did not conform to the simple first-order model.

- *Michaelis-Menton Decay Kinetics ($C_L > 0$, $K_b < 0$, $n < 0$) :*

$$r = \frac{K_b C}{C_L - C}$$

As a special case, when a negative reaction order n is specified, the Michaelis-Menton rate equation, shown above for a decay reaction. (For growth reactions the denominator becomes $C_L + C$). This rate equation is often used to describe enzyme-catalyzed reactions and microbial growth. It produces first order behavior at low concentrations and zero-order behavior at higher concentrations. Note that for decay reactions, C_L must be set higher than the initial concentration present.

Koechling (1998) has applied Michaelis-Menton kinetics to model chlorine decay in a number of different waters and found that both K_b and C_L could be related to the water's organic content and its ultraviolet absorbance as follows:

$$K_b = -0.32 UVA^{1.365} \frac{(100UVA)}{DOC}$$

$$C_L = 4.98 UVA - 1.91 DOC$$

where UVA = ultraviolet absorbance at 254 nm (1/cm) and DOC = dissolved organic carbon concentration (mg/L).

- *Zero-Order growth ($C_L = 0$, $K_b = 1$, $n = 0$)*

  $r = 1.0$

This special case can be used to model water age, where with each unit of time the "concentration" (i.e., age) increases by one unit.

The relationship between the bulk rate constant seen at one temperature (T_1) to that at another temperature (T_2) is often expressed using a van't Hoff – Arrehnius equation of the form :

$$K_{b2} = K_{b1}\theta^{T_2-T_1}$$

where θ is a constant. In one investigation for chlorine, θ was estimated to be 1.1 when T_1 was 20 deg. C (Koechling, 1998).

Pipe Wall Reactions

While flowing through pipes, dissolved substances can be transported to the pipe wall and react with material such as corrosion products or bio-film that are on or close to the wall. The amount of wall area available for reaction and the rate of mass transfer between the bulk fluid and the wall will also influence the overall rate of this reaction. The surface area per unit volume, which for a pipe equals 2 divided by the radius, determines the former factor. The latter factor can be represented by a mass transfer coefficient whose value depends on the molecular diffusivity of the reactive species and on the Reynolds number of the flow (Rossman et. al, 1994). For first order kinetics, the rate of a pipe wall reaction can be expressed as :

$$r = \frac{2K_w K_f C}{R(K_w + K_f)} \tag{3.34}$$

where K_w = wall reaction rate constant (length/time), K_f = mass transfer coefficient (length/time), and R = pipe radius.

For zero-order kinetics the reaction rate cannot be any higher than the rate of mass transfer, so

$$r = MIN(K_w, K_f C)(2/R) \tag{3.35}$$

where K_w now has units of mass/area/time.

Mass transfer coefficients are usually expressed in terms of a dimensionless Sherwood number (Sh) :

$$K_f = Sh\frac{D}{d} \tag{3.36}$$

in which D = the molecular diffusivity of the species being transported ($\text{length}^2/\text{time}$) and d = pipe diameter. In fully developed laminar flow, the average Sherwood number along the length of a pipe can be expressed as

$$Sh = 3.65 + \frac{0.0668(d/L)\mathrm{Re}\,Sc}{1 + 0.4\left[(d/L)\mathrm{Re}\,Sc\right]^{2/3}} \tag{3.37}$$

in which Re = Reynolds number and Sc = Schmidt number (kinematics' viscosity of water divided by the diffusivity of the chemical) (Edwards et.al, 1976).

For turbulent flow the empirical correlation of Notter and Sleicher (1971) can be used :

$$Sh = 0.0149\,\mathrm{Re}^{0.88}\,Sc^{1/3} \tag{3.38}$$

System of Equations

When applied to a network as a whole, equation (3.30), (3.31) and (3.32) represent a coupled set of differential/algebraic equations with time-varying coefficients that must be solved for C_i in each pipes i and C_s in each storage facilitys. This solution is subject to the following set of externally imposed conditions :

- Initial conditions that specify C_i for all x in each pipe i and C_s in each storage facilitys at time 0,
- Boundary conditions that specify values for $C_{k,ext}$ and $Q_{k,ext}$ for all time t at each node k which has external mass inputs
- Hydraulic conditions, which specify the volume Vs in each storage facilitys and the flow Qi in each, link i at all times t.

Extended Period Water Quality Simulation

Several approaches have been used to numerically model the transport and the fate of dissolved substances or simulating the spatial and temporal variations of water quality in water distribution system (Rossman and Boulos, 1996). These techniques range from the use of steady state to dynamic mathematical model formulations.

Steady state water quality models determine the movement of contaminants, their flow path and travel times through the network under steady state flow. Steady state models use the law of mass conservation to determine the spatial distribution of ultimate concentration of water quality constituents that will take place if the distribution system reaches hydraulic equilibrium. These methods provide intermittent assessment capabilities but point prediction of water quality is less feasible. Dynamic models rely upon a system simulation approach to determine the movement and spread of constituents under time varying demand, supply and hydraulic conditions. Since most of the process in water distribution networks are time dependent, dynamic modelling provides a more accurate and realistic portrayal of the actual operation of the system and the transient interaction of water quality and hydraulic behaviour.

Dynamic models of water quality can be classified spatially as Eularian and Langrangian models. Eularian models divide the pipe network into series of fixed, interconnected control volumes and record changes at the boundaries or within these volumes as water flows through them. Langrangian models track changes in a series of discrete parcels of water as they travel through the pipe network. These models can further be classified temporally as *time* driven and *event* driven. *Time* driven simulation updates the state of the water distribution network at fixed time intervals. *Even* driven simulation updates the state of the system only at time when a change actually occurs, such as when a new parcel of water reaches the end of pipe and mixed with water from other connection pipes.

The governing equations for EPANET's water quality solver are also based on the principles of the conservation of mass coupled with reaction kinetics and for simulator uses a Lagrangian time-based approach to track the fate of discrete parcels of water as they move along pipes and mix together at junctions between fixed-length time steps (Liou and Kroon, 1987). These water quality time steps are typically much shorter than the hydraulic time step (e.g., minutes rather than hours) to accommodate the short times of travel that can occur within pipes. As time progresses, the size of the most upstream segment in a pipe increases as water enters the pipe while an equal loss in size of the most downstream segment occurs as water leaves the link. The size of the segments in between these remains unchanged. (See Figure 3.1).

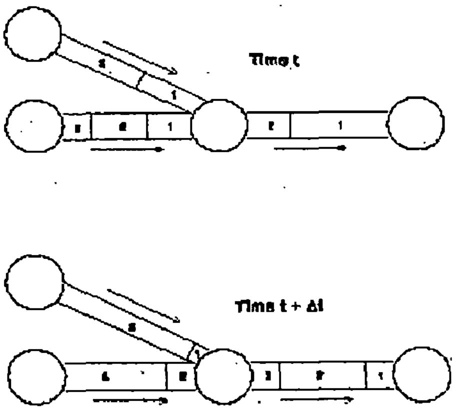


Figure 3.1. Behaviour of Segments in the Lagrangian Solution Method

The following steps occur at the end of each such time step:

1. The water quality in each segment is updated to reflect any reaction that may have occurred over the time step.
2. The water from the leading segments of pipes with flow into each junction is blended together to compute a new water quality value at the junction. The volume contributed from each segment equals the product of its pipe's flow rate and the time step. If this volume exceeds that of the segment then the segment is destroyed and the next one in line behind it begins to contribute its volume.
3. Contributions from outside sources are added to the quality values at the junctions. The quality in storage tanks is updated depending on the method used to model mixing in the tank (see below).
4. New segments are created in pipes with flow out of each junction, reservoir, and tank. The segment volume equals the product of the pipe flow and the time step. The segment's water quality equals the new quality value computed for the node.

To cut down on the number of segments, Step 4 is only carried out if the new node quality differs by a user-specified tolerance from that of the last segment in the outflow pipe. If the difference in quality is below the tolerance then the size of the current last segment in the outflow pipe is simply increased by the volume flowing into the pipe over the time step.

This process is then repeated for the next water-quality time step. At the start of the next hydraulic time step the order of segments in any links that experience a flow reversal is switched. Initially each pipe in the network consists of a single segment whose quality equals the initial quality assigned to the upstream node.

Basic Transport

EPANET's water quality simulator uses a Lagrangian time-based approach to track the fate of discrete parcels of water as they move along pipes and mix together at junctions between fixed-length time steps. These water quality time steps are typically much shorter than the hydraulic time step (e.g., minutes rather than hours) to accommodate the short times of travel that can occur within pipes.

The method tracks the concentration and size of a series of non-overlapping segments of water that fills each link of the network. As time progresses, the size of the most upstream segment in a link increases as water enters the link while an equal loss in size of the most downstream segment occurs as water leaves the link. The size of the segments in between these remains unchanged.

For each water quality time step, the contents of each segment are subjected to reaction, a cumulative account is kept of the total mass and flow volume entering each node, and the positions of the segments are updated. New node concentrations are then calculated, which include the contributions from any external sources. Storage tank concentrations are updated depending on the type of mixing model that is used (see below). Finally, a new segment will be created at the end of each link that receives inflow from a node if the new node quality differs by a user-specified tolerance from that of the link's last segment.

Initially each pipe in the network consists of a single segment whose quality equals the initial quality assigned to the upstream node. Whenever there is a flow reversal in a pipe, the pipe's parcels are re-ordered from front to back.

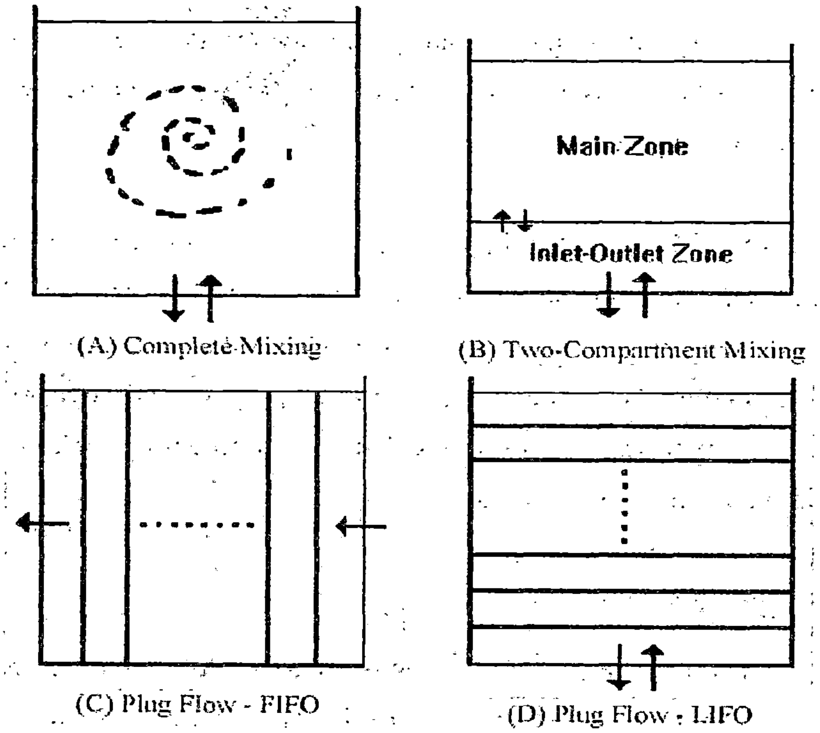
Mixing in Storage Tanks

EPANET can use four different types of models to characterize mixing within storage tanks as illustrated in Figure 3.2 :

- Complete Mixing
- Two-Compartment Mixing
- FIFO Plug Flow
- LIFO Plug Flow

The Complete Mixing model (Figure 3.2(a)) assumes that all water that enters a tank is instantaneously and completely mixed with the water already in the tank. It is the simplest form of mixing behavior to assume, requires no extra parameters to describe it, and seems to apply quite well to a large number of facilities that operate in fill-and-draw fashion.

Different models can be used with different tanks within a network.



(A) Complete Mixing (B) Two-Compartment Mixing

(C) Plug Flow - FIFO (D) Plug Flow - LIFO

Figure 3.2. Tank Mixing Models

The Two-Compartment Mixing model (Figure 3.2(b)) divides the available storage volume in a tank into two compartments, both of which are assumed completely mixed. The inlet/outlet pipes of the tank are assumed to be located in the first compartment. New water that enters the tank mixes with the water in the first compartment. If this compartment is full, then it sends its overflow to the second compartment where it completely mixes with the water already stored there. When water leaves the tank, it exits from the first compartment, which if full, receives an equivalent amount of water from the second compartment to make up the difference. The first compartment is capable of simulating short-circuiting between inflow and outflow while the second compartment can represent dead zones. The user must supply a single parameter, which is the fraction of the total tank volume devoted to the first compartment.

The FIFO Plug Flow model (Figure 3.2(c)) assumes that there is no mixing of water at all during its residence time in a tank. Water parcels move through the tank in a segregated fashion where the first parcel to enter is also the first to leave. Physically speaking, this model is most appropriate for baffled tanks that operate with simultaneous inflow and outflow. There are no additional parameters needed to describe this mixing model.

The LIFO Plug Flow model (Figure 3.2(d)) also assumes that there is no mixing between parcels of water that enter a tank. However in contrast to FIFO Plug Flow, the water parcels stack up one on top of another, where water enters and leaves the tank on the bottom. This type of model might apply to a tall, narrow standpipe with an inlet/outlet pipe at the bottom and a low momentum inflow. It requires no additional parameters be provided.

Water Quality Reactions

EPANET can track the growth or decay of a substance by reaction as it travels through a distribution system. In order to do this it needs to know the rate at which the substance reacts and how this rate might depend on substance concentration. Reactions can occur both within the bulk flow and with material along the pipe wall.

This is illustrated in Figure 3.3. In this example free chlorine (HOCl) is shown reacting with natural organic matter (NOM) in the bulk phase and is also transported through a boundary layer at the pipe wall to oxidize iron (Fe) released from pipe wall corrosion. Bulk fluid reactions can also occur within tanks. EPANET allows a modeler to treat these two reaction zones separately.

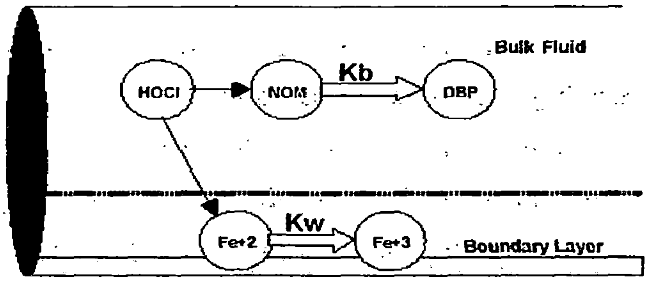


Figure 3.3. Reaction Zones Within a Pipe

Bulk Reactions

EPANET models reactions occurring in the bulk flow with n-th order kinetics, where the instantaneous rate of reaction (R in mass/volume/time) is assumed to be concentration-dependent according to

$$R = K_b C^n$$

Here K_b = a bulk reaction rate coefficient, C = reactant concentration (mass/volume), and n = a reaction order. K_b has units of concentration raised to the $(1-n)$ power divided by time. It is positive for growth reactions and negative for decay reactions.

EPANET can also consider reactions where a limiting concentration exists on the ultimate growth or loss of the substance. In this case the rate expression becomes

$$R = K_b (C_L - C)C^{(n-1)} \qquad \text{for } n > 0, K_b > 0$$

$$R = K_b (C - C_L)C^{(n-1)} \qquad \text{for } n > 0, K_b < 0$$

where C_L = the limiting concentration. Thus there are three parameters (K_b, C_L, and n) that are used to characterize bulk reaction rates. Some special cases of well-known kinetic models include the following :

Model	Parameters	Examples
First-Order Decay	$C_L = 0, K_b < 0, n = 1$	Chlorine
First-Order Saturation Growth	$C_L > 0, K_b > 0, n = 1$	Trihalomethanes
Zero-Order Kinetics	$C_L = 0, K_b \neq 0, n = 1$	Water Age
No Reaction	$C_L = 0, K_b = 0$	Fluoride Tracer

The K_b for first-order reactions can be estimated by placing a sample of water in a series of non-reacting glass bottles and analyzing the contents of each bottle at different points in time. If the reaction is first-order, then plotting the natural log (C_t/C_o) against time should result in a straight line, where C_t is concentration at time t and C_o is concentration at time zero. K_b would then be estimated as the slope of this line.

Bulk reaction coefficients usually increase with increasing temperature. Running multiple bottle tests at different temperatures will provide more accurate assessment of how the rate coefficient varies with temperature.

Wall Reactions

The rate of water quality reactions occurring at or near the pipe wall can be considered to be dependent on the concentration in the bulk flow by using an expression of the form

$$R = (A/V)K_wC^n$$

where K_w = a wall reaction rate coefficient and (A/V) = the surface area per unit volume within a pipe (equal to 4 divided by the pipe diameter). The latter term converts the mass reacting per unit of wall area to a per unit volume basis. EPANET limits the choice of wall reaction order to either 0 or 1, so that the units of K_w are either mass/area/time or length/time, respectively. As with K_b, K_w must be supplied to the program by the modeler. First-order K_w values can range anywhere from 0 to as much as 5 m/day.

K_w should be adjusted to account for any mass transfer limitations in moving reactants and products between the bulk flow and the wall. EPANET does this automatically, basing the adjustment on the molecular diffusivity of the substance being modeled and on the flow's Reynolds number.

The wall reaction coefficient can depend on temperature and can also be correlated to pipe age and material. It is well known that as metal pipes age their roughness tends to increase due to encrustation and tuburculation of corrosion products on the pipe walls. This increase in roughness produces a lower Hazen-Williams C-factor or a higher Darcy-Weisbach roughness coefficient, resulting in greater frictional head loss in flow through the pipe.

There is some evidence to suggest that the same processes that increase a pipe's roughness with age also tend to increase the reactivity of its wall with some chemical species, particularly chlorine and other disinfectants. EPANET can make each pipe's K_w be a function of the coefficient used to describe its roughness. A different function applies depending on the formula used to compute head loss through the pipe :

Head loss Formula	*Wall Reaction Formula*
Hazen-Williams	$Kw = F / C$
Darcy-Weisbach	$Kw = -F / \log(e/d)$

where C = Hazen-Williams C-factor, e = Darcy-Weisbach roughness, d = pipe diameter, and F = wall reaction - pipe roughness coefficient. The coefficient F must be developed from site-specific field measurements and will have a different meaning depending on which head loss equation is used. The advantage of using this approach is that it requires only a single parameter, F, to allow wall reaction coefficients to vary throughout the network in a physically meaningful way.

3.4. ILLUSTRATIVE EXAMPLE TO SHOW EXTENDED PERIOD SIMULATION USING EPANET

A typical real type water distribution network with pipe and node details has been shown in Figure 3.4. This network consists of 17 demand nodes and 21 pipes, with the demands and node elevations also diameter, length, roughness and status of each pipe listed in Table 3.4. For the purpose of illustration, four demand patterns are considered herein as shown in Figure 3.5. It is assumed that as the network consist of major pipelines only, not more than one pipeline will fail at a time. Therefore, there will be (X+1) number of possible states, where X is the number of pipelines in the network. For example, in the illustrative example, there are 21 pipelines, hereby, there will be 22 possible states, i.e., one as when all pipelines are working, and remaining 21 states correspond to each pipeline failing and all other working.

EPANET 2.0 model used in this study for hydraulic and water quality simulation requires an input of various nodes and pipe parameters; and water level bounds, initial level and filling schedule for the tanks. This input can be provided to EPANET 2.0 in the network or a text file format. The text input for this hypothetical illustrative example is given in appendix A. In the node parameters, the Ids, elevations, base demands and the pattern (number) is to be specified. For each pattern number, multipliers of the base demands are given in the [PATTERNS] section in appendix A. For the tank node, the ID, elevation (of the bottom of water column above the datum), initial, maximum and minimum water levels and the diameter is specified. The pipe parameters require ID of pipe, Ids of connected nodes, length, and diameter and friction coefficient for the pipe.

For illustrative water quality modelling, chlorine has been chosen as the parameter. Since it is a non-conservative parameter, the bulk and wall decay coefficients have been provided in [REACTIONS] section. Here, the first order bulk coefficient is taken as –1.2 m/day (negative sign shows decay) to be followed globally (i.e. for all pipes and tank of water distribution network) and first order global wall reaction (applicable to all the pipes) is taken as –0.2 m/day.

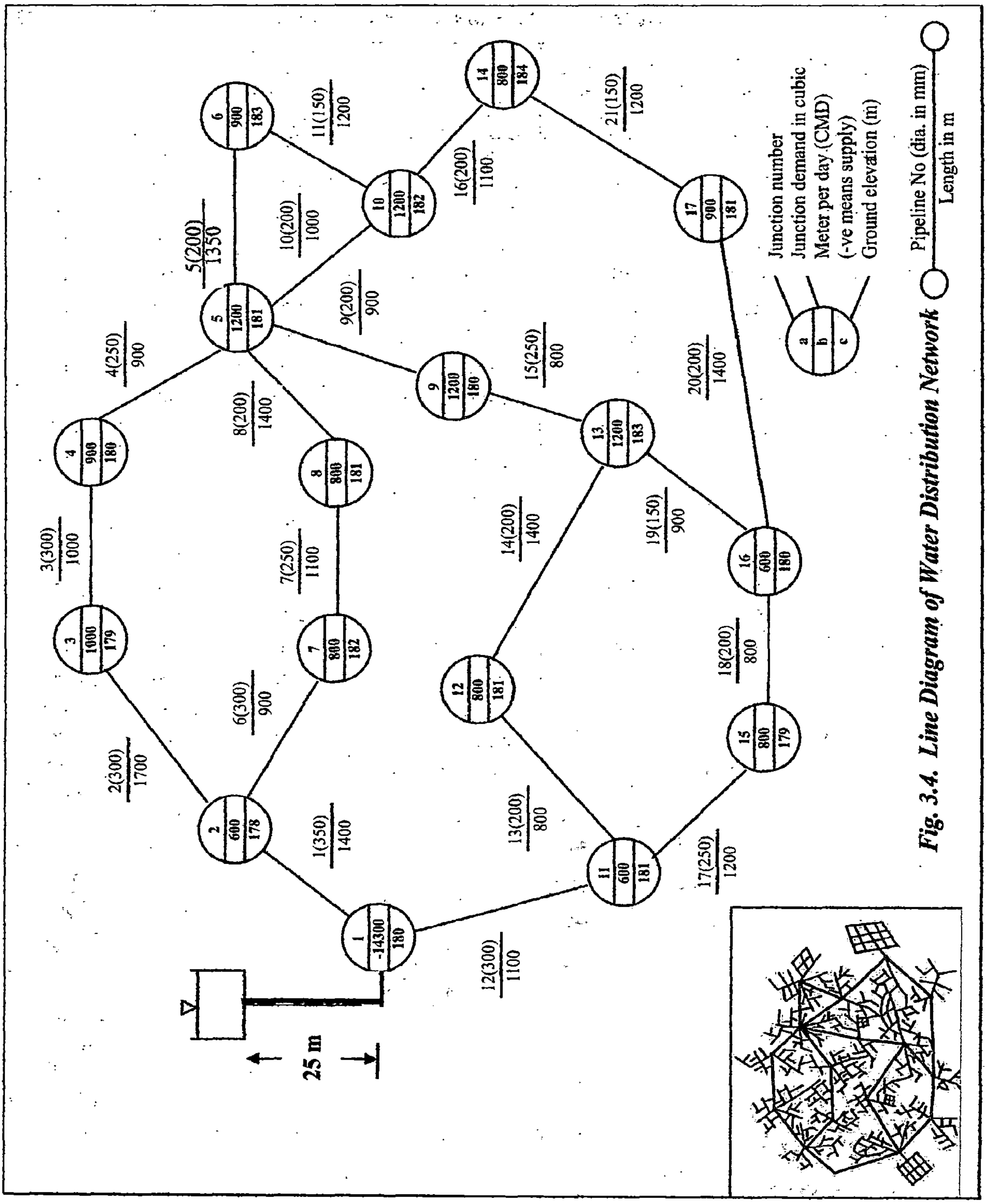


Fig. 3.4. Line Diagram of Water Distribution Network

Table 3.4. Network Characteristics

Network Table – Nodes			Network Table - Links				
Node ID	Elevation m	Base Demand CMD	Link ID	Length m	Diameter mm	Roughness	Status
Junc. 1	180	-14300	Pipe 1	1400	350	100	open
Junc. 2	178	600	Pipe 2	1700	350	100	open
Junc. 3	179	1000	Pipe 3	1000	300	100	open
Junc. 4	180	900	Pipe 4	900	250	100	open
Junc. 5	181	1200	Pipe 5	1350	200	100	open
Junc. 6	183	900	Pipe 6	900	300	100	open
Junc. 7	182	800	Pipe 7	1100	250	100	open
Junc. 8	181	800	Pipe 8	1400	200	100	open
Junc. 9	180	1200	Pipe 9	900	200	100	open
Junc. 10	182	1200	Pipe 10	1000	200	100	open
Junc. 11	181	600	Pipe 11	1200	150	100	open
Junc. 12	181	800	Pipe 12	1100	300	100	open
Junc. 13	183	1200	Pipe 13	800	200	100	open
Junc. 14	184	800	Pipe 14	1400	200	100	open
Junc. 15	179	800	Pipe 15	800	150	100	open
Junc. 16	180	600	Pipe 16	1100	200	100	open
Junc. 17	181	900	Pipe 17	1200	250	100	open
-	-	-	Pipe 18	800	200	100	open
-	-	-	Pipe 19	900	150	100	open
-	-	-	Pipe 20	1400	200	100	open
-	-	-	Pipe 21	1200	150	100	open

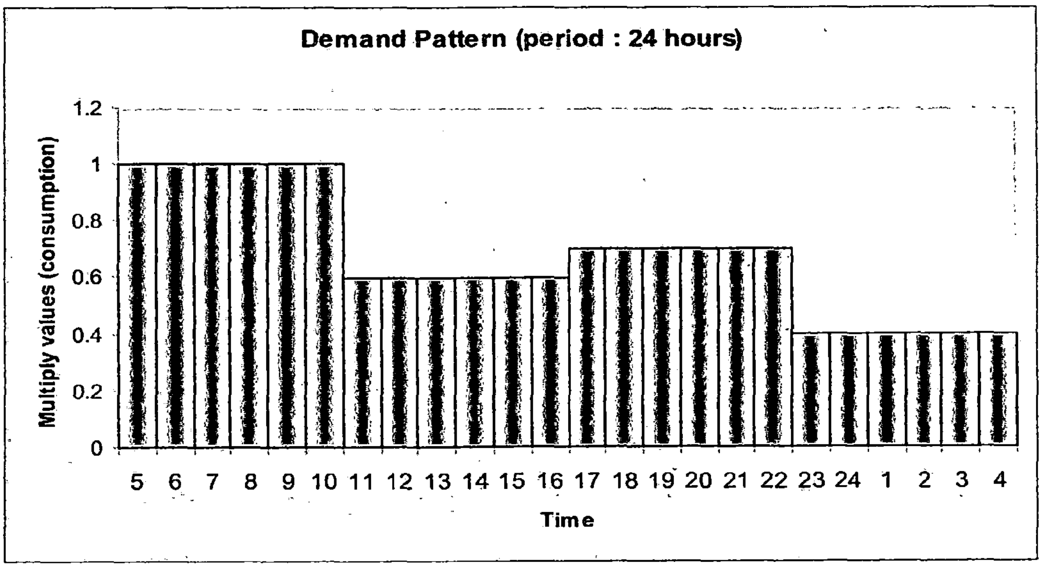


Fig. 3.5. Demand Time Pattern

This network is simulated hydraulically and qualitatively for 24 hours and the report start at 5 AM to provide stabilization of hydraulic and quality characteristics. For illustration, the node result at 12 hours (5 PM in the daily cycle) are shown in Table 3.5. The decay in chlorine concentration as water travels from the source (tank) towards downstream nodes can be clearly seen. To illustrative the temporal variation in chlorine concentration at a node, Figure 3.6 shows the daily cycle of concentration variation at node 5.

Table 3.5. Output from EPANET 2.0 at various nodes at 12 hours

Network Table - Nodes at 12:00 Hrs

Node ID	Demand CMD	Head m	Pressure m	Chlorine mg/L
Junc 1	-10010.00	215.00	35.00	0.35
Junc 2	420.00	211.51	33.51	0.32
Junc 3	700.00	210.05	31.05	0.26
Junc 4	630.00	208.87	28.87	0.23
Junc 5	840.00	207.30	26.30	0.20
Junc 6	630.00	206.11	23.11	0.21
Junc 7	560.00	210.77	28.77	0.28
Junc 8	560.00	209.50	28.50	0.24
Junc 9	840.00	206.96	26.96	0.23
Junc 10	840.00	205.91	23.91	0.17
Junc 11	420.00	212.20	31.20	0.32
Junc 12	560.00	209.62	28.62	0.28
Junc 13	840.00	207.61	24.61	0.21
Junc 14	560.00	205.74	21.74	0.23
Junc 15	560.00	210.10	31.10	0.28
Junc 16	420.00	207.81	27.81	0.25
Junc 17	630.00	206.27	25.27	0.19
Junc 18	0.00	215.00	35.00	0.57

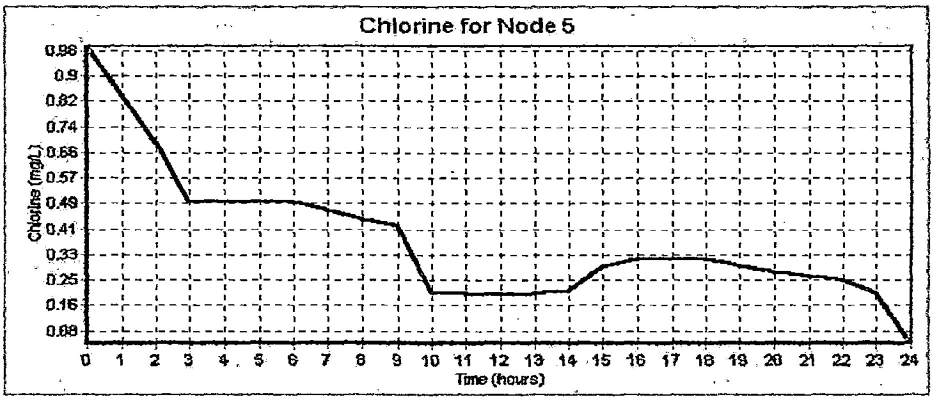


Figure 3.6. Temporal Variations in Nodal Chlorine Concentration

3.5. SUMMARY

Hydraulic and water quality modelling can produce quantity and quality effective designs as well as give good estimate of the changes occurring within a water distribution network. Computer aided hydraulic simulations are very convenient and fast for large networks and many models are available for this purpose.

There are many numerical methods of hydraulic and water quality modelling under steady state and dynamic flow conditions. EPANET is one of the most commonly used computer models for hydraulic and water quality simulations. Its features and working with this model has been explained. An illustrative example has been simulated hydraulically as well as qualitatively. The selected water distribution network has a large number of primary loops and its hydraulic analysis requires deployment of energy, head loss and loop equations simultaneously. Computer aided models greatly reduce the computational efforts and time for hydraulic analysis of such water distribution network for solving through iterations a large number of these equations out of which the head loss and loop equation are non-linier in nature. Chlorine is selected as the parameter for showing the partial and temporal various in water quality in the water distribution network.

CHAPTER 4

NETWORK PERFORMANCE AND RELIABILITY ANALYSIS

4.1. INTRODUCTION

The purpose of water distribution network is to deliver safe drinking water from treatment plants to consumers in adequate quantity. The level of service provided by a water distribution network is directly related to its reliability. Thus, reliability analysis is important and is carried out to estimate the capability of a water distribution network to provide the required service. Reliability analysis of urban water distribution network has become a prerequisite for allocation of funds for their installment, up-gradation and maintenance, etc.

Many studies have been carried out in the filed of mechanical and/or hydraulic reliability of a water distribution network. de Neufville, Schaake and Stafford (1971) were perhaps the first to introduce a quantitative criterion to study the overall performance of a water distribution network. Damelin, Shamir and Arad (1972) suggested a reliability model using the concept of annual reliability factor year y, i.e., R_y, as 1 minus the ratio of the shortfall of water supply during year y to the total demand during year y. Shortfall in supply were due to random failure of pumping equipment. The reliability model was used to compute the cost of marginal water obtained by improving reliability of the system through an additional well as source of water or augmentation of storage capacity to determine the desirability of improvement from cost consideration. The model, however, considered lumped demand. Shamir and Howard (1981) introduced two reliability factors : (1) discharge reliability factor; and (2) volume reliability factor.

The reliability factor of the system R_S was taken as the average of these two reliability factors. They illustrated how the reliability factors could be used to find the trade-off between storage and standby pumping capacity for a fixed reliability factor, and to plot iso-reliability curves to determine the least-cost combination of storage and standby pumping capacity. Rowell and Barnes (1982a) provided reliability in water distribution networks by satisfying demand at each node through two independent paths from the source. Initially, a least cost branched layout is determined. Loop forming links are then added, connecting branches of the tree, so that they can supply demand at the downstream nodes when links in the initial tree fail. However, the method sacrifices hydraulic consistency in search for the least cost solutions as shown by Goulter and Morgan (1984). Morgan and Goulter (1982, 1985a) and Goulter and Morgan (1985) developed an approach in which the layout of the network is optimally determined such that every node is forced to be connected by at least two links. The system is designed for a range of a combinations of critical flows, including fire flows and pipe failure conditions. However, the judgement of the designer is needed to define the worst location of broken pipe for each fire flow. Germanopoulos, Jowitt and Lumbers (1986) presented a methodology for assessing the security of the supply and level of service under failure events such as pipe break and source failure due to contamination or inadequate storage capacity. The level of service is assessed by dynamic node head analysis of the system considering failure occurrences and repair times. The methodology also examines management of the system to minimize the impacts on water supply due to failure events. Wagner, Shamir and Marks (1988b) introduced the concept of service head and minimum head at a demand node and a parabolic head-discharge. They used node head analysis (NHA) to find the available nodal heads and then decide the available flow at a demand node, giving either adequate-flow, partial-flow or no-flow condition. Since they used NHA only once to determine the available nodal flows and not repeatedly to achieve appropriate head-discharge relationship, as in node flow analysis the network behaviour under deficient conditions was rather approximate. They suggested several event-related, node-related, link-related and system-related reliability measures. Bao and Mays (1990) considered uncertainties in future demand, pressure head requirement and pipe roughness characteristics in their design model based on Monte Carlo simulation. They suggested two reliability parameters : (1) nodal reliability, the probability of the available nodal head lying between upper and lower bounds; and (2) system reliability, the minimum or the mean of the nodal reliabilities. Kessler, Ormsbee and Shamir (1990) proposed a methodology for the least-cost improvements in reliability of water distribution networks by explicitly incorporating topologic redundancy to sustain a single component (pipe or node) failure. Their approach is based on providing alternate paths and LP optimisation. Ormsbee and Kessler (1990) extended its application to upgrading single-source network that can sustain any single component (link or node) failure by considering two, overlapping spanning trees. Gupta and Bhave (1992) observed that the provision of simultaneous failure of particular group of links in a looped network provided more than adequate redundancy and thus the final solution was slightly sub optimal. Dhindhayalan (1994)[8] and Naik (1994)[8] improved the methodology to remove the additional redundancy and reduce the system cost. They also observed that if the overlapping spanning trees were not properly selected, demand failure might occur at some nodes even during a single link failure. Fujiwara and De Silva (1990) defined system reliability at the ratio of expected maximum flow to total system demand. They suggested to use of a method suggested by Carey and Hendrickson (1984) for evaluating the expected minimum flow of a capacitated network. Initially the network is optimally designed without considering reliability. Its reliability is then assessed. The system is then successively modified by increasing pipe sizes to obtain the desired reliability. However, they recognized that the actual behaviour of a network was different from what they presumed in their model and stated in conclusion that "... the flow capacity defined in the maximum flow model does not give a clear physical meaning, and system reliability estimated does not take into account the hydraulic consistency along each loop". Fujiwara and Tung (1991) improved the model of Fujiwara and De Silva (1990) by evaluating the measure of reliability using a non-linear maximum flow model so that it considered the hydraulic consistency along each loop. The link diameter is considered as a continuous variable and it is increased in fixed step sizes until the desired reliability is reached. Marginal increase in reliability and marginal increase in cost are evaluated for each link for the step size increase in link diameters and the link with the maximum ratio of these marginal values is selected for the diameter increase. For a symmetrical network subjected to a symmetrical loading, sizes of symmetrical links are increased simultaneously to get symmetrical solution. The drawbacks of the method are that it requires excessive computer time and the definition of flow capacity of a link used in the model has its limitations. Cullinane, Lansey and Mays (1992) proposed and LP optimisation model incorporating constraints that considered an availability measure through fuzzy relationship between available flow and pressure for partial-failure conditions. The nodal availability index gradually reduced from one for available HGL equal to desirable HGL to a pre-selected value (<1) for available HGL equal to minimum required HGL. Park and Liebman (1993) introduced the concept of allowable shortage fraction (ASF) to consider shortfalls in nodal demands. The ASF at a node indicates assured supply of some pre-selected percentage of the total demand during any link failure. The ASF constraints are then used in the head-dependent LPG optimisation model (Quindry, Brill and Liebman 1981). The model eliminates non-binding constraints and can include storage facilities to improve reliability. The initial design is iteratively modified until the available nodal HGL value are at least equal to the minimum required ones for only one HGL, the minimum-required one. Gupta and Bhave (1994a) introduced the performance of a water distribution network considering the availability of the total volume of water at individual nodes and for the entire network during the period of analysis based on a node reliability factor, volume reliability factor and network reliability factor. Kansal, M.L., Kumar, A. and Sharma, P.B. (1995) proposed an estimation of global reliability based on the concept of Appended Spanning Tree (AST). As the numerical value of pipeline break/repair rates are subject to errors, their effect on the reliability analysis. Kumar, A., Kansal, M.L. and Kumar, S. (1996) developed a probabilistic method combined with simulation study to compute the hydraulic reliability under the stochastic conditions of supply and demand. The supply and demand are random variables which depend upon various climatic conditions. Neelakantan, T.R. and Suribabu, C.R. (2005) proposed performance evaluation of an urban water distribution networks based on the *Link Important Measure*, the probability of pipe failure and

Network Effectiveness Index for finding the least cost at a given network by selecting different diameter of pipes.

Though mechanical and hydraulic aspects are necessary for assessing the reliability of a water distribution network, they are not sufficient. With the growing awareness of the negative impacts of water distribution network on water quality, the focus is now shifting towards reliability analysis of water quality in a water distribution network. Thus, a comprehensive reliability analysis of a water distribution network must consider the reliability of water quality in additional to mechanical and hydraulic reliability. Kansal, M.L, Arora, G. and Verma, S. (2004) introduced the concept of water quality reliability under booster chlorination. They evaluated the effect of pipe and BC station failure on residual chlorine concentration at various nodes of a water distribution network.

In this chapter, the concept and necessary background details of mechanical, hydraulic and water quality reliability are briefly described as these are substantially developed. Three parameters of reliability, namely : overall system hydraulic reliability, overall system quality reliability and network effectiveness index are discussed to evaluate performance of a water distribution network.

It is known that, nodal demands always fluctuate during a day, water level in tank change when tank is filled or emptied. Even though a network may have satisfactory performance at a particular point of time, it may not have satisfactory performance over a certain interval of time, for example during peak hours in a day in a fire-flow condition. In other side, the estimation of reliability in water distribution network under two major conditions, viz., (i) when all the components in the network are operational, and (ii) when some of the components in the network are non-operational is important. Therefore, to assess the overall performance of the network, it is preferable to carry out analysis not only under normal condition but also under abnormal condition. In learn how the system will respond under those conditions, simulation is one of the most commonly tools to reproduce the behaviour of the system. Simulation is the process of designing a model of a real system and conducting experiments with this model to observe the behaviour (within the limits imposed) of an existing or a proposed system. The main advantage of simulation models lies in their ability to accurately describe the reality. If a simulation model can be developed and is shown to represent a prototype system, it can provide insight about how the real system might perform over time under varying conditions. Thus, proposed configurations of projects can be evaluated to judge whether their performance would be adequate or not before investments are made. In a like manner, operating policies can be tested before they are implemented in actual control situations.

Usually, the structure or behaviour of the system being simulated is so complex that its analytical expression is not possible. A simulation model of a water resource system duplicates its operation with a defined operational policy, using the parameters of physical and control structures, time series of flows, demands, and the variables describing water quality, etc. The evaluation of the design parameters or operation policy is through the objective function (flow or demand related measures or economic indices) or some measure of reliability. Since simulation models do not use an explicit analytical procedure for determination of the best combination of the controlling variables, it is necessary to proceed by trial and error or follow a strategy of parameter sampling.

Since models are abstractions of reality, they usually do not describe all the features that are encompassed by a real-world situation. Only those aspects of the system that are relevant to the objective of the study are modelled so that solution is obtained at a reasonable cost and within a prescribed time frame. If the simulation model has to reproduce all the complexities of the prototype, it will be as complex as the prototype. Therefore, the model builder should attempt to model the detailed functioning of individual components to the necessary extent so as to meet the overall accuracy requirements while not making it unnecessarily complicated. In this study , Monte Carlo simulation is used. The method is illustrated with the help of an example.

4.2. MONTE CARLO SIMULATION

Design of real world systems is generally based on observed historical data. For example, the observed stream flow data are used in sizing a reservoir, historical traffic data is used in design of highways; observed data are used in design of customer services, etc. However, frequently the historical records are not long enough and the observed pattern of data is not likely to repeat exactly. The performance of a system critically depends on the extreme values of input variables and the historical data may not contain the entire range of input variables. There are many instances when a flood with peak value exceeding the historical records entered a reservoir.

An important conclusion from the above is that one does not get a complete picture of the system performance and risks involved when historical data are used in evaluation. Thus, for instance, the planner cannot determine the risks of a water supply system failing to meet the demands during its economic life because this requires a very large sample of data which are not commonly available.

For many systems, some or all inputs are random, system parameters are random, initial conditions may be random, and boundary condition(s) may also be random in nature. The probabilistic properties of these are known. For such systems, simulation experiments are conducted using a set of inputs which are synthetically (artificially) generated. While generating the inputs, it is ensured that the statistical properties of the random variables are preserved. Each simulation experiment with a particular set of inputs gives an answer. When many such experiments are conducted with different sets of inputs, a set of answers is obtained. These are statistically analysed to understand or forecast the behaviour of the system. This approach is known as Monte Carlo simulation, and using it, planners get better insight of the working of the system and can determine the risk of failures, e.g., chances of a reservoir running dry or a customer service centre failing to provide services within promised time.

Thus, Monte Carlo simulation technique aims at estimating stochastic or deterministic parameters based on random sampling. The principle behind this simulation technique is replacement of the given system under analysis by a system described by some known probability distribution and then drawing random samples from probability distribution by means of random numbers. In case it is not possible to describe the system in terms of standard probability distribution such as normal, Poisson, exponential, gamma, etc., an empirical probability distribution can be constructed.

The Monte Carlo simulation technique consists of following steps :

1. Setting up a probability distribution for the variables to be analysed.
2. Building a cumulative probability distribution for each random variable.
3. Assign an appropriate set of random numbers to represent value or range (interval) of values for each random variable.
4. Conduct the simulation experiment by means of random sampling.
5. Repeat step 4 until the required number of simulation run has been generated.
6. Design and implement a course of action and maintain control.

The main advantages of Monte Carlo simulation are that the system, its inputs, outputs, and parameters can be easily described. All the critical parameters of the system can be included in its description. The other advantages include saving in time and expenses. It is important to remember that the synthetically generated data are no substitute of the actual observed data but this is a useful pragmatic tool which allows the analyst to extract detailed information from the available data.

For the existing water distribution networks, the nodal demand often changes due to many factors such as new users or an increase in the number of existing users. Because of their randomness or uncertainty, the demands are considered as random variables. The hydraulic uncertainty due to the randomness of water demand can be incorporated by assigning an appropriate probability distribution and its parameters for the demand of flow rate over a time period. Water demand actually varies throughout the day and could be divided into different periods, each having a different demand level.

Since the reliability data for water distribution system are usually minimal, it may be difficult to select the probability distribution that should be used in generating demand at each node. Because of the lack of reliability data, it is also difficult in many cases to estimate the parameters for the distributions. This is a problem that exists regardless of the type of distribution that is used.

Demand requirements vary over a period of time. In this study, normal distribution is used. Thus, demand at any node can be estimated as:

$$Q_{estimated} = Q_{av.} + Z\sigma \tag{4.1}$$

in which $Q_{estimated}$ = generated nodal demand; $Q_{av.}$ = average nodal demand; σ = standard deviation of the nodal demand and Z = standardized variable of normal distribution.

Monte Carlo simulation requires the generation of a sequence of random numbers and such generation is an integral part of all discrete system simulation models. This sequence of random numbers helps in choosing random observations from the probability distribution.

A random number is a number in sequence of integer numbers between 0 to 9, whose probability of occurrence is same as that of any other number in the sequence. In the early days of mathematical simulation, mechanical means were employed to generate random numbers. The techniques that were used to generate random numbers were drawing cards from a pack, drawing numbered balls from a vessel, reading numbers from a telephone directory, etc. Printed tables of random numbers were also in use for quite some time. The Monte Carlo techniques have got this name because roulette wheels similar to those in use at Monte Carlo were used to generate random numbers.

4.3. TERMINOLOGY USED IN PERFORMANCE EVALUATION

The reliability of various components of the water distribution network is expressed in terms of probability of their uninterrupted operation through the period (0,t). For a repairable component, concept of available has wider applicability. Since, most of the components in a water distribution network are repairable and can put back into service after mechanical or electrical repairs, the terms availability and non-availability are defined taking into account the duration for which a particular component remains operational or non-operational. The subsequent section defines a few terms that have been used in this chapter to quantify availability and reliability.

4.3.1. Failure Density Function

In assessing system reliability, it is necessary to define and categorize modes of failure. Unfortunately, it is quite difficult to define failure in very clear terms, Complete and catastrophic failure is easy recognized, but sometimes, a system's performance deteriorates gradually over time and there is only a fine difference between the system success and failure. Basically, one the system proceed in a logical fashion and define the various system failure modes. Once the system function and failure modes are explicitly stated, probability statements can precisely quantify reliability.

Since the failure of a component is random nature, various probability distribution models are of great significance in order to derive hazard functions. Hazard function or the failure rate can be defined as the ratio of the number of failures in a time period to the total operational time.

Some of the commonly used probability models in reliability analysis are normal, lognormal, exponential, gamma, weibull and extreme value type. However, in most of the reliability analysis studies, exponential distribution is probably the most widely used because of its relative simplicity. The probability density function, f(t), in the exponential distribution is written as

$$f(t) = \lambda e^{-\lambda t} \tag{4.2}$$

where $t \geq 0$ and λ is the hazard function.

4.3.2. Reliability of a component

The Reliability R(t) of component is defined as the probability that the component experiences no failure during the time interval (0,*t*), given that it is new or repaired at time zero. In other words, the reliability is the probability that the time to failure of the component exceeds t. Mathematically, it is expressed as

$$R(t) = \int^{\infty} f(t)dt \tag{4.3}$$

where, f(t) is the probability density function of time to failure of the concerned component.

4.3.3. Mean Time to Failure

Classically, for a mechanical system, time state can be divided into two categories :

i) Operational.
ii) Non-operational.

Operational state of the component is that state in which the component performs its function satisfactory. The component is in non-operational state during repair or maintenance that results in component shutdown. These states again depend upon the failure and repair rate of the component.

Mean Time To Failure (*MTTF*) is the expected value of the mean time between failure. It is usually expressed in units of time. Also, when the system being evaluated is renewed through maintenance or repair, *MTTF* is also known as the expected life E(t). The expected life, or the expected time during which a component will perform successfully is defined as

$$E(t) = \int^{\infty} f(t)dt \tag{4.4}$$

4.3.4. Mean Time to Repair

The Mean Time To Repair (*MTTR*) is the expected value of the time between two consecutive failures. Figure 4.1 shows the schematics of MTTF and MTTR.

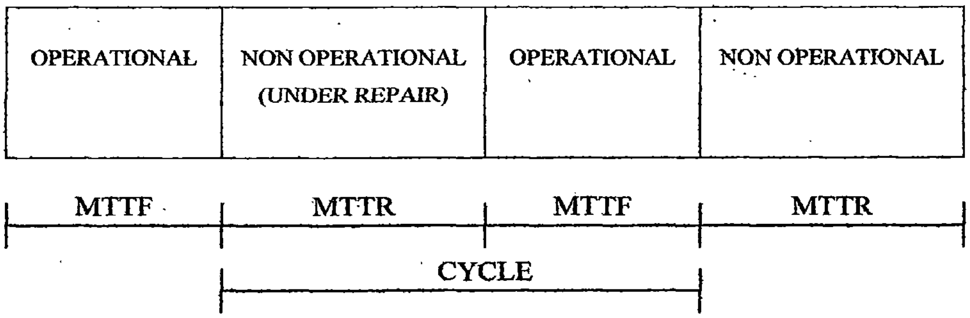


Figure 4.1 State Space for a Single Component

4.3.5. Availability

Availability A(t) of component at time *t* is the probability that the component is in operating condition at time *t*, given that the component was as good as new at time zero. Availability generally differs from reliability because reliability requires the continuation of the operational state over the whole time interval (0,t); whereas, in availability the time during the interval for which component remains in operational state (which depends upon the frequency and duration of failure/repair of the component) is considered. Availability is always greater than reliability for a repairable component and is equal to reliability for non-repairable one.

Availability is expressed as the percentage of the total interval time. As shown in Figure 4.1, the cycle time for a repairable component consists of operation time and repair time. If *MTTF* and *MTTR* of a component '*i*' are known, then availability (A_i) can be written mathematically as

$$A_i^r = \frac{MTTF_i}{MTTF_i + MTTR_i} \qquad (4.5)$$

And, non-availability (UA_i) can be written as

$$UA_i = 1 - A_i \tag{4.6}$$

In the case of water distribution network, it is very difficult to compute analytically the availability of pipelines as there is no comprehensive database of failure and repair of the components. However, Mays et.el. (1989) have give some idea of mathematical availability of components based upon the failure records of various components in USA. These value differ for difference conditions and for different interval of time. Regression equations can be developed for the break rates of water mains using the data from the specific system. Walski and Pelliccia (1982), developed break rate regression equations for Binghamton, New York. On similar lines, one can develop the regression equations for break and repair rates depending upon local conditions that are system specific. For example, Kansal (1997) assumed the following equations for stationary values of *MTTF*, *MTTR* and break rates for Indian conditions :

$$MTTF = \frac{1}{N_i x L_i} \tag{4.7}$$

$$N_i = 2.5\exp(0.04(t - 0.1D)) \text{ for Pit Cast Iron pipe} \tag{4.8}$$

$$MTTR = 9.6D^{0.4} \tag{4.9}$$

where, N_i = break/km length/year, t = age of pipe in years, D = pipe diameter in mm and L_i= length of pipe in km.

.4. MECHANICAL RELIABILITY

There are two major conditions under which the estimation of reliability in water distribution network is important. These are : (i) the normal working conditions when all the components in the network are operational, and (ii) when some of the component in the network are non-operational.

In mechanical reliability, physical connectivity of demand node(s) with source(s) of supply is studied under two broad categories : (i) node pair connectivity, and (ii) global connectivity. Node pair connectivity estimates the probability that a given demand node in the water distribution network remains connected to minimum one source. The global connectivity estimates the probability that all the demand nodes in the water distribution network will remain connected to at least one source even when some of the pipelines in the network are non-operational. This can be achieved using the concepts of pathsets/cutsets, and/or the concept of non-pathsets/cutsets (tree, and appended spanning trees) (Kansal, 1997).

The occurrence probability of a system can be computed by the multiplying the probability of occurrence of an event, can be written as

$$R(0) = \prod_{i=1}^{n} A(i) \quad \text{for no link failure} \tag{4.10}$$

$$R(r) = UA(i) * \prod_{\substack{i=1 \\ i \neq r}}^{n} A(i) \quad \text{for single pipe failure} \tag{4.11}$$

4.5. HYDRAULIC RELIABILITY

In hydraulic reliability, the probability of receiving water with desired pressure is assessed. If the pressure in inadequate, the nodes of the water distribution network will not be able to receive the required demand even if there is physical connectivity. Hydraulic reliability is usually estimated under two possible conditions, viz., (i) when all pipes in the water distribution network are fully operational; and (ii) when some of the pipelines are non-operational.

When the network is fully operational, following possible situations may rise :

1. Due to stochasticity of supply and demand, it is quite likely that during the periods of sufficient supply, demand may be very high.
2. Even during the periods of sufficient supply to cater to the demands, it is quite likely that with the aging of pipelines the head loss increases. The increases head loss in various pipelines will reduce the residual pressure head at various nodes, which in turn result in partial/no-flow at some of the demand nodes.

3. Existing algorithms for analysing the water distribution network may become inapplicable under condition of partial/no-flow at some of the demand nodes.

These parameters should be taken into consideration at the time of design itself. It is assumed that design parameters have taken care of these and when the water distribution network is fully operational its hydraulic reliability is quite high. However, under crisis event, when some of the pipelines in the network are non-operational, the computation of hydraulic reliability becomes much more difficult because of the following reasons :

1. It is difficult to estimate the time and location of pipeline(s) failure in the network as there can be a large number of possible combination of such pipeline(s) failures.
2. The simulation and analysis of flow and pressure under pipeline failure condition is not so easy re-routing of flow takes place in a very complex manner.

Under these conditions, hydraulic reliability is estimated from the hydraulic simulator of the water distribution network. The water supplied to a jth node will depend on the head attainable at that node. For each node, two head limits must be given :

1. a minimum head (H^{min}) and
2. a service head (H^{avl}).

The system is said to be performing normally only when, for each node, all the imposed demands can be met with head above the service limit. If, however, at some nodes in the reduced system, the head is below the service limit, it is assumed that at that node the system cannot supply the full demand. Many relationships are available for estimating this reduced supply. There methods can be classified in two categories : (1) node head analysis, and (2) node flow analysis.

In Nodal Head Analysis, the available nodal flows are given by equation (4.12a).

$$q_j^{avl} = q_j^{req}, \text{ for all demand nodes } j \qquad (4.12a)$$

Herein it presumed that a nodal demand is always satisfied ($q_j^{avl} = q_j^{req}$) irrespective of the available HGL at node j, H_j^{avl}, as shown in Fig. 4.2(a). This presumption is acceptable as long as $H_j^{avl} \geq H_j^{\min}$, the minimum HGL at node j for flow to occur, a condition satisfied in the normal working condition of a network. However, a network may become temporarily deficient during an excessive demand for during a pipe break or a pump failure. It is necessary to predict the performance of the network in such a temporary deficient condition (Gupta and Bhave 1996b). In a temporarily deficient condition a network may not be able to satisfy the demands at all nodes; rather, it may satisfy the demands completely at some nodes, partially at some other nodes, while no water may be available at the remaining nodes. Thus, analysis technique that would determine the available nodal flows lying between 0 and q_j^{req}, i.e., analysis based on equation (4.12b) would be necessary.

$$q_j^{req} \geq q_j^{avl} \geq 0, \text{for all demand nodes } j \tag{4.12b}$$

Since this type of analysis determines the available nodal flows, Bhave (1980b, 1981a,b, 1991) termed it *node flow analysis* in contrast to the node head analysis that determines the available nodal heads for the required nodal flows.

For deficient situation, Goulter and Coals (1986) and Su et al. (1987) introduced a concept of nodal available (flow is available at a node) based on

$$q_j^{avl} = q_j^{req}, \text{if } H_j^{avl} \geq H_j^{des} \tag{4.13a}$$

$$q_j^{avl} = 0, \text{ if } H_j^{avl} < H_j^{\min} \tag{4.13b}$$

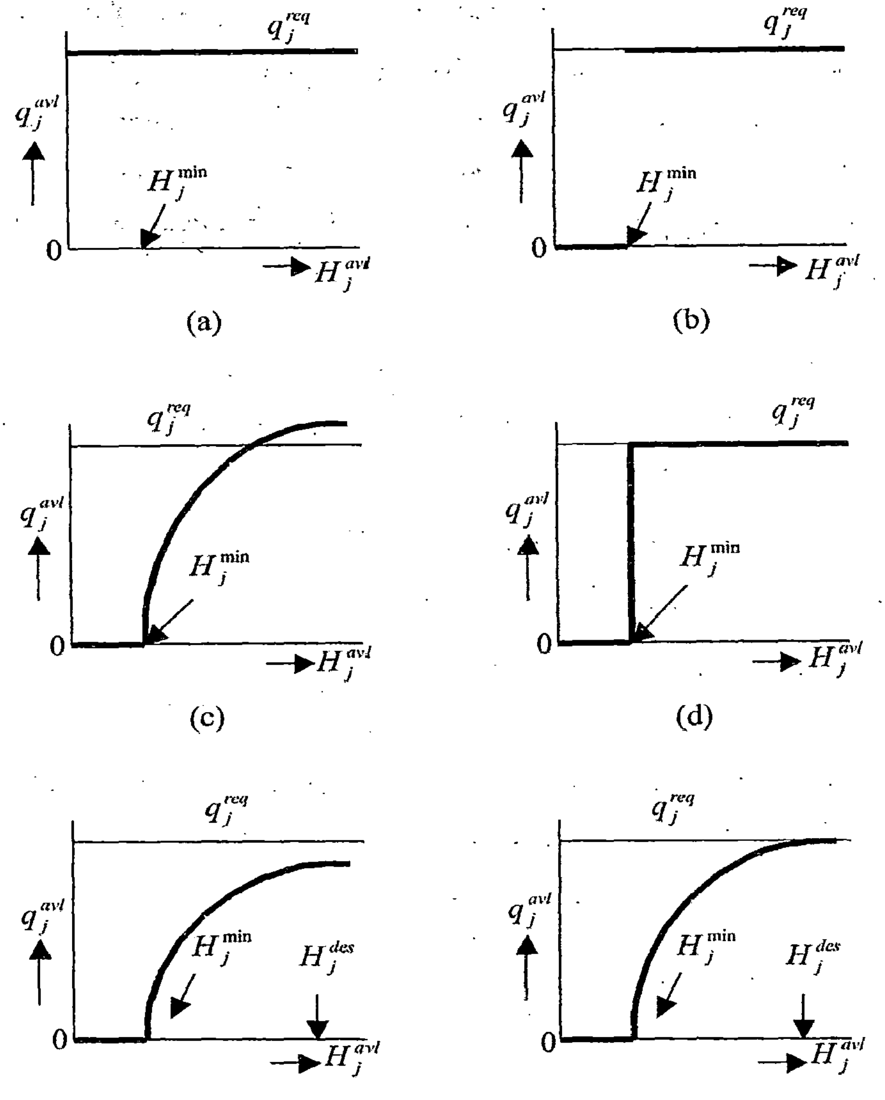
as shown in Fig. 4.2(b).

Reddy and Elango (1989, 1991) proposed head dependent analysis assuming uncontrolled outlets with the nodal flow wholly dependent on the residual heads, $H_j^{avl} - H_j^{\min}$ (Fig. 4.2(c)) according to a relationship

$$q_j^{avl} = S_j(H_j^{avl} - H_j^{\min})^{0.5} \tag{4.14a}$$

or $$H_j^{avl} = H_j^{\min} + R_j \left(q_j^{avl}\right)^2 \tag{4.14b}$$

in which S_j and R_j are node constants.



(a) (b)

(c) (d)

(e) (f)

Figure 4.2. Available flows at demand nodes: (a) NHA solution; (b) solution using equations (4.13a-b); (c) solution using equations (4.14a-b); (d) NFA solution using equations (4.15a-c); (e) NFA solution using equation (4.16a-b) and (f) NFA solution using equations (4.18a-c)

Neither of these approaches can be used to show the deficient network performance necessary for simulation of models. As shown later, equations (4.13a-b) provide an anomalous situation since they disregard a partial flow condition $(0 < q_j^{avl} < q_j^{req})$ that may be available at a node, while equations (4.14a-b) give unrestricted flow at a node, violating assumption that even through more water may be available at a node, the performance of the piezometric head at the node. As observed by Bao and Mays (1990), the available flows and heads at demand nodes must be considered simultaneously for better prediction of deficient network performance.

In node flow analysis, Bhave (1980b, 1981a, b) was perhaps the first to consider nodal flows and heads simultaneously and suggested a relationship (Fig. 4.2(d)) that can be expressed as

$$q_j^{avl} = q_j^{req}, \text{(adequate flow), if } H_j^{avl} \geq H_j^{\min} \tag{4.15a}$$

$$0 < q_j^{avl} < q_j^{req}, \text{(partial flow), if } H_j^{avl} = H_j^{\min} \tag{4.15b}$$

$$q_j^{avl} = 0, \text{(no flow), if } H_j^{avl} \leq H_j^{\min} \tag{4.15c}$$

Germanopoulos (1985) also considered nodal flows and heads simultaneously and suggested a relationship (Fig. 4.2(e)) that can be expressed as

$$q_j^{avl} = q_j^{req}\left(1 - 10^{-\beta}\right), \text{ if } H_j^{avl} > H_j^{\min} \tag{4.16a}$$

$$q_j^{avl} = 0, \text{ if } H_j^{avl} \leq H_j^{\min} \tag{4.16b}$$

in which

$$\beta = c_j\left[\left(H_j^{avl} - H_j^{\min}\right)/\left(H_j^{des} - H_j^{\min}\right)\right]$$

Wagner, Shamir and Marks (1988a,b) and Chandapillai (1991) suggested a parabolic relationship (Fig. 4.2(f)) for nodal head between $H_j^{\min}$ and H_j^{des}. The relationship is

$$H_j^{des} = H_j^{\min} + R_j\left(q_j^{req}\right)^n \tag{4.17}$$

in which n = an exponent, usually taken 2. Thus,

$$q_j^{avl} = q_j^{req}, \text{(adequate flow), if } H_j^{avl} \geq H_j^{des} \tag{4.18a}$$

$$0 < q_j^{avl} = q_j^{req}\left[\left(H_j^{avl} - H_j^{\min}\right)/\left(H_j^{des} - H_j^{\min}\right)\right]^{1/n} < q_j^{req}, \quad (partial \text{ flow), if } H_j^{\min} < H_j^{avl} < H_j^{des} \tag{4.18b}$$

$$q_j^{avl} = 0, \text{(no flow), if } H_j^{avl} < H_j^{\min} \tag{4.18c}$$

In this study, reduced supply is computed using equation (4.18b). The rationale for equation (4.18b) is that hydraulic laws for flow through pipe show that the flow is proportional to the square root of the pressure head. The supply reduction from normal to no flow is related to the square root of the pressure head. However, no supply is possible if the pressure head at the node is below the minimum head as given is equation (4.18c).

It is assumed that as the water distribution networks under analysis consists of only main pipelines, the failure probability of pipes is very low. Also, it is assumed that no two pipes fail at the same time. The node hydraulic reliability factor is defined as the ratio of the discharge supplied at a node to the total required supply at that node, can be written as :

$$RH_{js} = \frac{Q_{js}^{avl}}{Q_{js}^{req}} \tag{4.19}$$

in which Q_{js}^{avl}= available discharge rate at node j during state s; Q_{js}^{req}= required discharge rate at node j during state s; j = subscript denoting demand node and s = subscript denoting state.

4.6. WATER QUALITY RELIABILITY

As discussed earlier, for any component of water distribution networks, there are two possible states viz. operational and non-operational (failure). For fully operational water distribution networks, direct water quality modelling can be used to find out the residual disinfectant at every node. When, any of the pipeline fails, the flows, velocity and the residence time changes in the pipes. As a result, the residual chlorine concentration levels at certain node may fall below the minimum desired level. The minimum desired level for the residual chlorine concentration is taken as 0.2 mg/L. The problem is to find the reliability water quality in terms of residual disinfectant for such conditions.

In this study, the water quality reliability analysis is perform under the condition of pipe failure, the chlorine concentration reaching at various nodes is obtained using a suitable water quality simulation model by eliminating one pipe at a time. The water quality reliability factor at a node "j" and a state "s" is taken as

$$\begin{aligned} RQ_j &= 1 \quad \text{for } C_j \geq C_{\min} \\ RQ_j &= 0 \quad \text{for } C_j < C_{\min} \end{aligned} \tag{7.20}$$

4.7. OVERALL SYSTEM RELIABILITY PARAMETERS

The performance of a water distribution network considering the availability of total volume of water at individual nodes and for the entire network during the period of analysis can described by : (1) overall system hydraulic reliability (*RHSO_j*); (2) overall system quality reliability (*RQSO_j*); and (3) network effectiveness index (NEI).

1. Overall System Hydraulic Reliability

In general, *Overall Nodal Hydraulic Reliability* (*RHO_j*) for node *j* can be compute by multiplying the probability of occurrence of an event with the hydraulic reliability factor under the event divided by the probability of occurrence of the system. Under the assumption that not more than one pipeline can fail at a given time. Thus, overall nodal hydraulic reliability for water distribution network containing 'n' number of links, can be written as :

$$RHO_j = \frac{R(0) * RH_0 + \sum_{j=1}^{n} R(r) * RH_j}{P}, \text{ for all nodes } j \tag{4.21}$$

in which $R(0)$ = the probability of no link failure; $R(r)$ = the probability of one pipe failure during state s; RH_0 = nodal hydraulic reliability factor of no link failure; RH_j = nodal hydraulic reliability factor of one pipe failure during state s; P = probability occurrence of the network; and j = subscript denoting demand node.

Overall System Hydraulic Reliability ($RHSO_j$) can be defined as the geometric mean of the combine nodal reliabilities in the system. Thus, overall system hydraulic reliability for node j,

$$RSHO_{jf} = \left[\prod_{j=1}^{J} RHO_j \right]^{1/j} \tag{4.22}$$

in which RHO_j = overall nodal hydraulic reliability; j = subscript denoting demand node; and f = number of demand pattern.

For a real time state in which multiple demand pattern exist, the reliability are to be estimated using the weighted time-average of the reliability for each demand pattern. For 'f' demand pattern, the overall system hydraulic reliability can be written as follows

$$RSHO_j = \sum_{x=1}^{f} \frac{RSHO_{jf}\, t_f}{T} \tag{4.23}$$

in which $RSHO_j$ = overall system hydraulic reliability during time period x; t_f = length of time period x; T = total number of simulation; j = subscript denoting demand node; s = subscript denoting state and f = number of demand pattern.

2. **Overall System Quality Reliability**

Overall Nodal Quality Reliability (RQO_j) can be compute by multiplying the probability of occurrence of an event with the quality reliability factor under the event divided by the probability of occurrence of the system. Thus, overall nodal quality reliability parameter for node j,

$$RQO_j = \frac{R(0) * RQ_0 + \sum_{j=1}^{n} R(r) * RQ_j}{P}, \text{ for all nodes } j \tag{4.24}$$

in which *R(0)* = the probability of no link failure; *R(r)* = the probability of one pipe failure during state *s*; RQ_0 = nodal quality reliability factor of no link failure; RQ_j = nodal quality reliability factor of one pipe failure during state *s*; *P* = probability occurrence of the network; and *j* = subscript denoting demand node.

In a similar manner as given in equations (4.22) and (4.23), the *Overall System Quality Reliability* ($RQSO_j$) can be defined as the geometric mean of the combine nodal reliabilities in the system. Thus, overall system quality reliability for node *j*,

$$RSQO_{jf} = \left[\prod_{j=1}^{J} RQO_j\right]^{1/j} \tag{4.25}$$

$$RSQO_j = \sum_{x=1}^{f} \frac{RSQO_{jf}\, t_f}{T} \tag{4.26}$$

in which RQO_j = overall nodal quality reliability; $RSQO_j$ = overall system quality reliability during time period *x*; t_f = length of time period *x*; *T* = total number of simulation; *j* = subscript denoting demand node; and *f* = number of demand pattern.

3. Network Effectiveness Index

A link may be very important according to *Link Importance Measure* (*LI*), whereas the probability of failure that link may be less. Otherwise, a link may be relatively less important according to link importance measure, but may have a high probability for failure. Thus, considering either link importance measure alone or probability of failure of links alone may not be appropriate, while a combined measure is more appropriate.

Bouchard and Goulter (1989) defined the link importance measure (*LI*), for a given link *i* as the proportion of the demand in the network as a whole that is not supplied when the link in question has failed (Mays, 2000). The *Link Importance Measure* of a given link *I* as calculated as

$$LI_i = \frac{(D - F_i)}{D} \tag{4.27}$$

where LI_i is Link importance measure of link *i*, *D* is total demand within the network and F_i is total demand that can be supplied when link *i* fails. The link importance measure is an indicator of the relative value of a link to the network as a whole. Once the link importance measures of all links are determined, one can identify the links in which failure results in a major collapse in service.

Network effectiveness can be evaluated based on the link importance measure and the probability of failure of each link. Network effectiveness index can serve as a tool for water engineers in selecting the best configuration that will have a good reliability with cost effectiveness (Neelakantan and Suribabu, 2005). Mathematically, it can be expressed as

$$NEI_{AVG} = 1 - \frac{\sum_{i=1}^{i=NP} LI_i A_i}{NP} \tag{4.28}$$

If link importance measure (LI_i) value is zero for the links in a network, it indicates that the network can satisfy its intended mission under failure of any one pipe of the system. If the probability of failure of all pipes is zero, and whatever be the link importance measure, the NEI will be one. The value of NEI varies from 0 for the worst case to one for the best case.

4.8. ILLUSTRATIVE EXAMPLE

The computation of reliability of a water distribution network requires enumerating various combinations of pipelines linking the sources with all the demand nodes. The illustrative water distribution network considered in previous chapter consists of 17 demand nodes. The standard deviation of demand varies for different demand nodes which depends on climatic conditions of the area and the affecting factor of losses and wastes. For illustration purpose, standard deviation is assumed as 200 CMD for demand nodes less than 1,000 CMD and 300 CMD for demands more than 1,000 CMD. The maximum pressure is set up according to the structural capabilities of pipes and other network elements, so as to avoid leakage (here 17 m is used). The minimum pressure requirement is there obviously in order to ensure supply but also to avoid pressure problems such as cavitations across the network. In this case 12 m pressure is used. It is assumed that as the network consist of major pipelines only, not more than one pipeline will fail at a time. Therefore, there will be (X+1) number of possible states, where X is the number of pipelines in the network. For example, in the illustrative example, there are 21 pipelines, hereby, there will be 22 possible states, i.e., one as when all pipelines are working, and remaining 21 states correspond to each pipeline failing and all other working.

As discussed earlier, to assess the performance of the network, it is preferable to carry out analysis not only under normal condition but also under abnormal conditions. Monte Carlo simulation is used to respond under abnormal conditions. Monte Carlo simulation requires the generation of a sequence of random number. The normal random number (*RN*) has a mean of $\frac{1}{2}$ and a variance of $\frac{1}{12}$ are generated by using Microsoft Excel spreadsheet as shown in Table 4.1 to 4.5. From the normal random number (Table 4.1 to 4.5), demand at each node (Q_d) can be calculated using the statistical normal distribution chosen as shown in Table 4.6.

Table 4.1. Normal Random Number Generating with mean = 0.5019 and standard deviation = 0.0830

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	0.434	0.492	0.561	0.521	0.475	0.543	0.365	0.465	0.588	0.282	0.518	0.546	0.473	0.524	0.460	0.532	0.392	0.415	0.523	0.497	0.518	0.535	0.438	0.655	0.574
2	0.482	0.550	0.603	0.558	0.604	0.375	0.584	0.458	0.609	0.485	0.395	0.574	0.489	0.476	0.375	0.554	0.459	0.454	0.610	0.466	0.368	0.450	0.517	0.528	0.343
3	0.475	0.517	0.554	0.527	0.624	0.600	0.490	0.419	0.519	0.477	0.368	0.434	0.521	0.529	0.529	0.529	0.591	0.571	0.612	0.635	0.627	0.553	0.449	0.461	0.342
4	0.477	0.501	0.442	0.499	0.621	0.444	0.519	0.681	0.330	0.518	0.556	0.560	0.427	0.418	0.557	0.499	0.681	0.535	0.537	0.598	0.691	0.571	0.522	0.532	0.575
5	0.449	0.503	0.631	0.488	0.541	0.473	0.381	0.553	0.566	0.596	0.443	0.545	0.444	0.459	0.520	0.520	0.540	0.598	0.422	0.511	0.519	0.540	0.630	0.531	0.472
6	0.500	0.586	0.533	0.509	0.482	0.556	0.733	0.402	0.446	0.500	0.576	0.380	0.430	0.495	0.629	0.618	0.546	0.463	0.491	0.490	0.505	0.734	0.558	0.556	0.534
7	0.665	0.359	0.471	0.416	0.623	0.523	0.459	0.554	0.435	0.454	0.365	0.718	0.511	0.438	0.476	0.526	0.572	0.544	0.446	0.499	0.313	0.417	0.565	0.526	0.468
8	0.417	0.503	0.477	0.574	0.521	0.623	0.343	0.694	0.546	0.643	0.515	0.561	0.518	0.491	0.599	0.450	0.593	0.575	0.471	0.417	0.548	0.650	0.631	0.525	0.579
9	0.646	0.492	0.442	0.390	0.513	0.443	0.548	0.387	0.418	0.445	0.525	0.494	0.545	0.419	0.517	0.399	0.508	0.363	0.535	0.456	0.485	0.477	0.463	0.546	0.505
10	0.501	0.494	0.440	0.562	0.488	0.369	0.409	0.436	0.474	0.562	0.479	0.632	0.552	0.584	0.464	0.513	0.544	0.456	0.327	0.497	0.447	0.623	0.464	0.612	0.423
11	0.508	0.530	0.394	0.597	0.639	0.336	0.585	0.424	0.475	0.523	0.532	0.473	0.579	0.630	0.583	0.578	0.636	0.433	0.480	0.514	0.368	0.450	0.680	0.449	0.403
12	0.481	0.572	0.356	0.500	0.409	0.473	0.392	0.566	0.560	0.519	0.510	0.452	0.509	0.387	0.534	0.406	0.555	0.504	0.549	0.502	0.540	0.518	0.369	0.526	0.543
13	0.489	0.661	0.597	0.435	0.485	0.542	0.618	0.472	0.591	0.541	0.372	0.440	0.447	0.462	0.559	0.530	0.353	0.593	0.476	0.457	0.504	0.498	0.435	0.586	0.626
14	0.426	0.659	0.356	0.531	0.503	0.566	0.351	0.485	0.302	0.399	0.607	0.331	0.477	0.398	0.498	0.436	0.534	0.437	0.632	0.401	0.389	0.423	0.539	0.377	0.444
15	0.503	0.508	0.394	0.424	0.482	0.472	0.484	0.458	0.438	0.533	0.542	0.406	0.369	0.416	0.517	0.496	0.415	0.570	0.620	0.472	0.624	0.533	0.547	0.629	0.642
16	0.390	0.482	0.381	0.662	0.532	0.500	0.377	0.505	0.427	0.445	0.518	0.535	0.536	0.531	0.581	0.401	0.515	0.418	0.516	0.411	0.610	0.579	0.387	0.506	0.439
17	0.500	0.559	0.555	0.455	0.478	0.527	0.432	0.536	0.414	0.468	0.359	0.451	0.417	0.457	0.589	0.429	0.434	0.444	0.531	0.610	0.504	0.474	0.573	0.452	0.540
18	0.581	0.436	0.448	0.661	0.495	0.564	0.519	0.457	0.388	0.406	0.638	0.607	0.557	0.484	0.577	0.574	0.464	0.521	0.491	0.591	0.494	0.470	0.601	0.532	0.518
19	0.549	0.529	0.530	0.449	0.563	0.627	0.507	0.484	0.441	0.555	0.560	0.564	0.407	0.592	0.420	0.492	0.398	0.556	0.441	0.446	0.500	0.501	0.406	0.523	0.451
20	0.437	0.524	0.533	0.400	0.452	0.488	0.508	0.602	0.395	0.370	0.357	0.188	0.615	0.461	0.613	0.461	0.659	0.398	0.613	0.556	0.512	0.468	0.585	0.436	0.680
21	0.437	0.521	0.619	0.541	0.696	0.329	0.419	0.558	0.485	0.397	0.528	0.660	0.402	0.510	0.469	0.661	0.511	0.625	0.452	0.456	0.401	0.557	0.444	0.479	0.401
22	0.439	0.519	0.512	0.430	0.478	0.476	0.486	0.519	0.528	0.379	0.466	0.370	0.488	0.587	0.488	0.639	0.525	0.431	0.415	0.603	0.439	0.604	0.426	0.565	0.526
23	0.381	0.413	0.539	0.578	0.481	0.459	0.495	0.516	0.449	0.393	0.319	0.501	0.475	0.419	0.397	0.583	0.529	0.457	0.549	0.646	0.379	0.495	0.662	0.479	0.606
24	0.566	0.450	0.535	0.485	0.541	0.343	0.484	0.461	0.576	0.292	0.473	0.478	0.438	0.503	0.463	0.440	0.501	0.479	0.530	0.635	0.559	0.351	0.427	0.422	0.532
25	0.629	0.596	0.617	0.561	0.460	0.432	0.289	0.286	0.531	0.514	0.453	0.501	0.317	0.449	0.511	0.564	0.614	0.348	0.765	0.556	0.442	0.678	0.437	0.556	0.457
26	0.394	0.507	0.466	0.364	0.433	0.558	0.495	0.523	0.516	0.575	0.559	0.629	0.428	0.344	0.388	0.556	0.582	0.499	0.405	0.505	0.376	0.386	0.461	0.507	0.435
27	0.581	0.499	0.509	0.519	0.445	0.413	0.487	0.368	0.509	0.498	0.527	0.507	0.656	0.577	0.546	0.415	0.491	0.400	0.624	0.546	0.517	0.674	0.432	0.531	0.518
28	0.418	0.457	0.574	0.478	0.461	0.506	0.619	0.547	0.625	0.382	0.584	0.311	0.491	0.451	0.346	0.410	0.473	0.498	0.693	0.668	0.428	0.401	0.442	0.487	0.491
29	0.502	0.577	0.344	0.492	0.603	0.417	0.479	0.619	0.538	0.475	0.447	0.481	0.560	0.555	0.493	0.527	0.652	0.480	0.564	0.426	0.700	0.486	0.591	0.523	0.492
30	0.445	0.598	0.619	0.385	0.463	0.379	0.489	0.551	0.585	0.377	0.565	0.476	0.468	0.470	0.522	0.427	0.537	0.548	0.602	0.511	0.616	0.428	0.597	0.418	0.494
31	0.586	0.342	0.444	0.480	0.537	0.354	0.491	0.517	0.432	0.444	0.482	0.491	0.381	0.488	0.462	0.600	0.363	0.509	0.506	0.596	0.364	0.533	0.508	0.521	0.420
32	0.501	0.521	0.566	0.494	0.575	0.426	0.547	0.663	0.579	0.465	0.587	0.426	0.635	0.654	0.596	0.565	0.399	0.505	0.683	0.668	0.568	0.669	0.617	0.502	0.679
33	0.615	0.471	0.507	0.637	0.712	0.517	0.491	0.405	0.481	0.522	0.458	0.574	0.427	0.633	0.461	0.436	0.564	0.502	0.406	0.650	0.316	0.526	0.566	0.374	0.412
34	0.302	0.503	0.326	0.541	0.557	0.490	0.416	0.519	0.419	0.492	0.577	0.383	0.480	0.450	0.513	0.564	0.482	0.478	0.545	0.388	0.613	0.404	0.472	0.428	0.479
35	0.597	0.530	0.502	0.563	0.538	0.502	0.461	0.439	0.483	0.539	0.528	0.513	0.600	0.432	0.357	0.416	0.500	0.575	0.576	0.371	0.469	0.598	0.596	0.675	0.428
36	0.602	0.475	0.464	0.510	0.511	0.472	0.474	0.466	0.503	0.613	0.538	0.519	0.544	0.380	0.538	0.473	0.375	0.630	0.584	0.568	0.521	0.529	0.541	0.684	0.462
37	0.463	0.554	0.304	0.572	0.553	0.367	0.360	0.282	0.585	0.469	0.350	0.524	0.408	0.547	0.608	0.534	0.664	0.401	0.495	0.380	0.534	0.489	0.500	0.544	0.472
38	0.394	0.517	0.604	0.572	0.632	0.517	0.509	0.445	0.600	0.530	0.422	0.403	0.559	0.568	0.447	0.516	0.540	0.468	0.513	0.378	0.368	0.608	0.398	0.465	0.511
39	0.498	0.556	0.648	0.484	0.670	0.533	0.624	0.533	0.507	0.454	0.488	0.539	0.606	0.579	0.462	0.442	0.665	0.517	0.511	0.441	0.579	0.325	0.449	0.548	0.537
40	0.561	0.453	0.551	0.480	0.528	0.562	0.491	0.594	0.436	0.451	0.392	0.570	0.509	0.516	0.484	0.436	0.410	0.641	0.555	0.545	0.383	0.443	0.604	0.465	0.653
Mean	0.496	0.513	0.499	0.508	0.535	0.477	0.480	0.496	0.493	0.475	0.487	0.494	0.492	0.494	0.504	0.504	0.519	0.496	0.532	0.514	0.491	0.516	0.513	0.517	0.503
Std. Dev	0.082	0.065	0.092	0.072	0.074	0.080	0.088	0.092	0.078	0.080	0.082	0.101	0.077	0.075	0.072	0.071	0.089	0.074	0.087	0.087	0.099	0.094	0.083	0.072	0.084

Table 4.2. Normal Random Number Generating with mean = 0.4979 and standard deviation = 0.0834

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	0.547	0.310	0.272	0.506	0.493	0.502	0.330	0.359	0.489	0.414	0.507	0.615	0.430	0.524	0.523	0.583	0.458	0.525	0.467	0.510	0.477	0.610	0.593	0.569	0.386
2	0.500	0.576	0.523	0.484	0.571	0.301	0.476	0.470	0.344	0.487	0.479	0.325	0.564	0.457	0.543	0.511	0.511	0.546	0.440	0.334	0.559	0.537	0.597	0.477	0.548
3	0.650	0.559	0.521	0.525	0.526	0.599	0.347	0.399	0.549	0.460	0.521	0.384	0.549	0.546	0.479	0.462	0.470	0.294	0.576	0.615	0.534	0.483	0.503	0.434	0.618
4	0.585	0.370	0.480	0.381	0.471	0.461	0.269	0.479	0.620	0.515	0.540	0.466	0.479	0.396	0.478	0.561	0.574	0.471	0.443	0.542	0.469	0.632	0.500	0.457	0.471
5	0.538	0.528	0.507	0.316	0.329	0.594	0.489	0.503	0.417	0.469	0.534	0.324	0.550	0.495	0.512	0.422	0.599	0.415	0.384	0.423	0.462	0.585	0.541	0.554	0.452
6	0.475	0.495	0.467	0.489	0.491	0.354	0.458	0.585	0.479	0.424	0.560	0.540	0.515	0.663	0.563	0.443	0.549	0.611	0.568	0.434	0.322	0.594	0.542	0.540	0.333
7	0.471	0.586	0.469	0.467	0.460	0.467	0.590	0.491	0.603	0.418	0.555	0.621	0.455	0.462	0.392	0.418	0.501	0.526	0.566	0.470	0.450	0.530	0.492	0.496	0.414
8	0.509	0.541	0.480	0.540	0.526	0.523	0.419	0.478	0.387	0.477	0.424	0.687	0.519	0.440	0.487	0.496	0.490	0.683	0.517	0.512	0.529	0.416	0.608	0.511	0.562
9	0.562	0.562	0.456	0.406	0.476	0.617	0.574	0.277	0.362	0.708	0.475	0.474	0.350	0.533	0.456	0.486	0.533	0.519	0.604	0.473	0.444	0.506	0.504	0.487	0.426
10	0.573	0.580	0.428	0.446	0.494	0.437	0.465	0.423	0.480	0.459	0.585	0.426	0.326	0.471	0.386	0.303	0.530	0.510	0.465	0.449	0.501	0.640	0.564	0.501	0.553
11	0.328	0.601	0.392	0.497	0.449	0.491	0.475	0.471	0.498	0.507	0.669	0.426	0.540	0.513	0.338	0.355	0.405	0.449	0.633	0.454	0.475	0.534	0.486	0.517	0.454
12	0.487	0.345	0.407	0.490	0.539	0.450	0.577	0.392	0.538	0.437	0.474	0.449	0.540	0.572	0.527	0.656	0.400	0.391	0.514	0.466	0.507	0.461	0.465	0.545	0.537
13	0.488	0.397	0.565	0.536	0.530	0.626	0.650	0.447	0.510	0.616	0.417	0.429	0.533	0.511	0.400	0.549	0.657	0.589	0.400	0.529	0.359	0.477	0.659	0.445	0.643
14	0.616	0.498	0.374	0.342	0.603	0.429	0.385	0.491	0.568	0.512	0.446	0.406	0.484	0.466	0.517	0.503	0.679	0.553	0.493	0.500	0.384	0.461	0.549	0.472	0.552
15	0.545	0.520	0.507	0.466	0.398	0.488	0.567	0.617	0.506	0.639	0.329	0.337	0.577	0.360	0.494	0.495	0.528	0.488	0.425	0.596	0.475	0.528	0.651	0.523	0.452
16	0.425	0.560	0.532	0.484	0.651	0.559	0.596	0.505	0.453	0.625	0.603	0.461	0.573	0.553	0.428	0.520	0.592	0.452	0.624	0.567	0.484	0.465	0.611	0.721	0.403
17	0.444	0.530	0.591	0.355	0.379	0.530	0.461	0.589	0.507	0.539	0.453	0.564	0.601	0.531	0.507	0.546	0.482	0.492	0.590	0.518	0.487	0.379	0.395	0.472	0.457
18	0.662	0.592	0.537	0.465	0.521	0.746	0.495	0.526	0.506	0.454	0.392	0.248	0.446	0.462	0.494	0.305	0.423	0.522	0.488	0.392	0.518	0.506	0.562	0.525	0.541
19	0.448	0.346	0.637	0.444	0.474	0.334	0.452	0.633	0.609	0.542	0.408	0.412	0.528	0.504	0.628	0.496	0.527	0.450	0.479	0.586	0.441	0.713	0.503	0.488	0.395
20	0.577	0.462	0.454	0.599	0.553	0.601	0.446	0.580	0.479	0.654	0.562	0.623	0.542	0.471	0.570	0.512	0.536	0.354	0.491	0.442	0.504	0.395	0.343	0.541	0.523
21	0.594	0.530	0.470	0.320	0.560	0.439	0.644	0.655	0.492	0.527	0.518	0.491	0.510	0.538	0.521	0.520	0.411	0.555	0.595	0.318	0.602	0.556	0.578	0.605	0.659
22	0.350	0.623	0.512	0.514	0.446	0.529	0.378	0.526	0.638	0.591	0.500	0.409	0.522	0.463	0.352	0.342	0.399	0.418	0.453	0.526	0.566	0.602	0.443	0.533	0.463
23	0.561	0.482	0.447	0.495	0.604	0.598	0.453	0.514	0.673	0.645	0.514	0.392	0.572	0.556	0.560	0.511	0.621	0.406	0.463	0.432	0.539	0.557	0.498	0.394	0.426
24	0.612	0.423	0.445	0.458	0.524	0.697	0.614	0.427	0.460	0.482	0.580	0.465	0.637	0.482	0.447	0.507	0.389	0.522	0.398	0.437	0.662	0.447	0.629	0.503	0.498
25	0.586	0.619	0.488	0.612	0.419	0.699	0.600	0.622	0.567	0.590	0.500	0.484	0.431	0.603	0.564	0.451	0.616	0.496	0.445	0.479	0.495	0.368	0.496	0.551	0.491
26	0.458	0.337	0.488	0.659	0.422	0.597	0.615	0.498	0.414	0.484	0.351	0.568	0.357	0.577	0.514	0.498	0.514	0.411	0.423	0.398	0.466	0.468	0.487	0.377	0.604
27	0.518	0.579	0.352	0.415	0.454	0.474	0.664	0.417	0.514	0.512	0.498	0.412	0.443	0.409	0.511	0.505	0.487	0.422	0.480	0.688	0.505	0.812	0.517	0.503	0.424
28	0.615	0.433	0.360	0.383	0.517	0.490	0.598	0.523	0.576	0.535	0.479	0.423	0.479	0.565	0.650	0.571	0.445	0.605	0.377	0.534	0.493	0.445	0.475	0.371	0.449
29	0.507	0.595	0.472	0.531	0.397	0.594	0.578	0.583	0.371	0.473	0.633	0.632	0.464	0.576	0.620	0.420	0.477	0.428	0.500	0.445	0.441	0.215	0.628	0.496	0.480
30	0.638	0.487	0.546	0.405	0.596	0.398	0.565	0.364	0.467	0.337	0.543	0.404	0.570	0.392	0.388	0.650	0.384	0.531	0.303	0.519	0.487	0.478	0.611	0.487	0.506
31	0.336	0.529	0.448	0.370	0.468	0.410	0.543	0.451	0.651	0.535	0.420	0.482	0.573	0.545	0.271	0.595	0.521	0.513	0.460	0.581	0.585	0.458	0.258	0.448	0.579
32	0.621	0.429	0.609	0.612	0.525	0.513	0.520	0.555	0.532	0.533	0.502	0.547	0.489	0.428	0.609	0.589	0.396	0.512	0.542	0.600	0.470	0.564	0.490	0.416	0.524
33	0.394	0.388	0.477	0.513	0.415	0.670	0.496	0.438	0.516	0.476	0.614	0.580	0.463	0.478	0.420	0.493	0.479	0.406	0.555	0.450	0.572	0.554	0.425	0.485	0.521
34	0.545	0.364	0.435	0.393	0.551	0.500	0.337	0.529	0.498	0.460	0.561	0.482	0.470	0.495	0.449	0.472	0.526	0.594	0.451	0.464	0.493	0.453	0.485	0.371	0.727
35	0.546	0.525	0.618	0.434	0.465	0.536	0.507	0.553	0.439	0.604	0.486	0.486	0.503	0.523	0.475	0.558	0.516	0.480	0.482	0.486	0.394	0.417	0.588	0.497	0.357
36	0.424	0.645	0.530	0.509	0.472	0.462	0.609	0.454	0.469	0.462	0.342	0.574	0.364	0.452	0.721	0.314	0.502	0.537	0.631	0.628	0.641	0.403	0.418	0.569	0.557
37	0.343	0.391	0.459	0.483	0.535	0.472	0.528	0.404	0.364	0.431	0.418	0.521	0.553	0.606	0.432	0.480	0.567	0.451	0.522	0.529	0.574	0.545	0.549	0.617	0.627
38	0.663	0.590	0.466	0.385	0.467	0.451	0.592	0.490	0.632	0.517	0.476	0.433	0.480	0.401	0.440	0.612	0.560	0.535	0.415	0.506	0.494	0.475	0.455	0.486	0.472
39	0.455	0.520	0.379	0.398	0.613	0.528	0.514	0.508	0.464	0.463	0.428	0.554	0.614	0.593	0.429	0.454	0.567	0.430	0.523	0.506	0.595	0.372	0.438	0.517	0.592
40	0.499	0.421	0.285	0.567	0.621	0.409	0.566	0.584	0.492	0.427	0.573	0.561	0.453	0.372	0.518	0.400	0.443	0.407	0.455	0.395	0.585	0.488	0.559	0.521	0.442
Mean	0.517	0.497	0.472	0.467	0.500	0.514	0.511	0.495	0.503	0.511	0.497	0.478	0.501	0.500	0.490	0.489	0.507	0.487	0.491	0.493	0.501	0.503	0.517	0.500	0.503
Std. Dev	0.091	0.093	0.081	0.082	0.072	0.100	0.096	0.082	0.082	0.079	0.079	0.096	0.073	0.070	0.090	0.087	0.075	0.077	0.076	0.078	0.071	0.104	0.084	0.068	0.087

Table 4.3. Normal Random Number Generating with mean = 0.4955 and standard deviation = 0.0847

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	0.438	0.608	0.529	0.329	0.568	0.432	0.498	0.491	0.433	0.292	0.436	0.490	0.550	0.593	0.651	0.642	0.471	0.410	0.529	0.546	0.623	0.632	0.626	0.438	0.322
2	0.486	0.553	0.503	0.420	0.556	0.613	0.501	0.560	0.413	0.570	0.528	0.327	0.412	0.643	0.553	0.461	0.617	0.520	0.461	0.544	0.455	0.518	0.510	0.592	0.559
3	0.517	0.530	0.490	0.463	0.443	0.297	0.495	0.652	0.552	0.525	0.568	0.529	0.554	0.368	0.400	0.486	0.274	0.625	0.427	0.497	0.451	0.604	0.570	0.647	0.470
4	0.447	0.437	0.365	0.450	0.501	0.347	0.385	0.535	0.372	0.641	0.412	0.624	0.389	0.499	0.466	0.348	0.532	0.371	0.540	0.580	0.543	0.659	0.390	0.392	0.396
5	0.395	0.510	0.407	0.627	0.485	0.534	0.502	0.404	0.490	0.602	0.374	0.561	0.654	0.667	0.554	0.443	0.362	0.635	0.557	0.436	0.367	0.393	0.522	0.529	0.527
6	0.521	0.317	0.484	0.519	0.422	0.453	0.521	0.414	0.546	0.574	0.479	0.387	0.377	0.526	0.447	0.502	0.451	0.610	0.569	0.538	0.502	0.256	0.556	0.307	0.393
7	0.498	0.574	0.665	0.571	0.710	0.515	0.489	0.401	0.493	0.550	0.505	0.390	0.514	0.488	0.407	0.534	0.495	0.481	0.548	0.451	0.618	0.591	0.448	0.629	0.412
8	0.592	0.590	0.487	0.605	0.270	0.543	0.471	0.567	0.538	0.585	0.354	0.462	0.417	0.378	0.635	0.652	0.413	0.507	0.667	0.517	0.552	0.571	0.484	0.486	0.481
9	0.515	0.559	0.712	0.407	0.434	0.484	0.432	0.493	0.626	0.529	0.495	0.679	0.411	0.472	0.522	0.512	0.337	0.475	0.422	0.582	0.512	0.436	0.509	0.445	0.497
10	0.519	0.457	0.399	0.439	0.491	0.445	0.494	0.534	0.355	0.388	0.550	0.420	0.473	0.403	0.553	0.480	0.406	0.462	0.318	0.536	0.533	0.461	0.548	0.610	0.624
11	0.539	0.458	0.369	0.634	0.586	0.447	0.418	0.352	0.696	0.284	0.462	0.637	0.451	0.587	0.438	0.278	0.618	0.410	0.522	0.512	0.416	0.442	0.431	0.722	0.445
12	0.569	0.579	0.594	0.626	0.516	0.530	0.524	0.526	0.355	0.552	0.614	0.529	0.611	0.485	0.633	0.445	0.573	0.641	0.567	0.535	0.451	0.489	0.486	0.631	0.558
13	0.459	0.582	0.466	0.521	0.470	0.417	0.429	0.479	0.515	0.537	0.437	0.597	0.347	0.532	0.413	0.488	0.397	0.535	0.659	0.569	0.488	0.509	0.681	0.620	0.650
14	0.530	0.386	0.418	0.417	0.506	0.507	0.506	0.582	0.453	0.465	0.593	0.512	0.613	0.610	0.445	0.458	0.512	0.573	0.621	0.439	0.508	0.562	0.448	0.529	0.459
15	0.389	0.395	0.527	0.284	0.547	0.481	0.402	0.516	0.530	0.596	0.439	0.599	0.408	0.505	0.692	0.429	0.671	0.606	0.631	0.466	0.500	0.383	0.423	0.532	0.509
16	0.567	0.493	0.342	0.572	0.601	0.626	0.522	0.519	0.461	0.437	0.544	0.527	0.513	0.509	0.499	0.459	0.499	0.497	0.516	0.492	0.481	0.384	0.627	0.454	0.758
17	0.661	0.498	0.440	0.394	0.456	0.641	0.585	0.441	0.592	0.317	0.560	0.461	0.499	0.459	0.543	0.473	0.569	0.448	0.413	0.436	0.414	0.387	0.476	0.490	0.550
18	0.566	0.507	0.506	0.503	0.480	0.491	0.410	0.512	0.513	0.486	0.438	0.552	0.358	0.564	0.607	0.425	0.453	0.494	0.620	0.548	0.476	0.414	0.550	0.570	0.391
19	0.418	0.447	0.619	0.536	0.421	0.534	0.477	0.458	0.559	0.483	0.446	0.542	0.577	0.577	0.488	0.528	0.456	0.427	0.602	0.638	0.414	0.592	0.517	0.504	0.474
20	0.467	0.466	0.477	0.525	0.569	0.434	0.411	0.658	0.625	0.495	0.440	0.537	0.455	0.504	0.418	0.515	0.463	0.531	0.463	0.482	0.477	0.370	0.355	0.593	0.554
21	0.396	0.434	0.394	0.458	0.366	0.538	0.408	0.545	0.551	0.511	0.510	0.449	0.558	0.618	0.395	0.547	0.353	0.405	0.585	0.341	0.560	0.571	0.395	0.496	0.478
22	0.538	0.341	0.598	0.588	0.523	0.528	0.525	0.497	0.349	0.435	0.315	0.655	0.464	0.577	0.343	0.486	0.349	0.532	0.565	0.414	0.582	0.368	0.508	0.513	0.519
23	0.512	0.502	0.511	0.419	0.459	0.404	0.552	0.429	0.514	0.392	0.507	0.516	0.488	0.510	0.463	0.428	0.515	0.401	0.332	0.490	0.405	0.703	0.366	0.458	0.575
24	0.417	0.424	0.560	0.496	0.514	0.593	0.476	0.490	0.504	0.523	0.467	0.527	0.635	0.458	0.559	0.522	0.421	0.445	0.418	0.477	0.621	0.421	0.499	0.479	0.469
25	0.362	0.537	0.434	0.668	0.584	0.503	0.590	0.474	0.570	0.576	0.625	0.481	0.479	0.409	0.460	0.507	0.613	0.572	0.534	0.654	0.476	0.635	0.481	0.550	0.533
26	0.508	0.537	0.573	0.395	0.368	0.586	0.454	0.482	0.539	0.569	0.427	0.384	0.429	0.391	0.404	0.310	0.369	0.675	0.473	0.560	0.470	0.467	0.590	0.513	0.592
27	0.472	0.576	0.372	0.505	0.438	0.565	0.502	0.546	0.352	0.773	0.518	0.341	0.537	0.687	0.542	0.303	0.358	0.454	0.444	0.433	0.390	0.495	0.549	0.437	0.568
28	0.417	0.545	0.394	0.472	0.605	0.484	0.535	0.506	0.312	0.533	0.537	0.542	0.402	0.397	0.429	0.506	0.553	0.480	0.431	0.524	0.454	0.381	0.516	0.482	0.400
29	0.611	0.430	0.479	0.499	0.286	0.254	0.452	0.530	0.456	0.484	0.565	0.511	0.432	0.515	0.642	0.494	0.483	0.581	0.409	0.626	0.614	0.600	0.633	0.556	0.632
30	0.591	0.462	0.457	0.538	0.592	0.556	0.418	0.367	0.445	0.590	0.449	0.576	0.358	0.519	0.549	0.494	0.480	0.324	0.559	0.537	0.534	0.475	0.567	0.441	0.454
31	0.418	0.485	0.511	0.473	0.539	0.515	0.591	0.535	0.382	0.277	0.388	0.567	0.513	0.427	0.432	0.495	0.599	0.408	0.551	0.731	0.457	0.472	0.542	0.412	0.529
32	0.671	0.445	0.465	0.471	0.539	0.608	0.517	0.500	0.527	0.527	0.377	0.434	0.486	0.450	0.407	0.509	0.402	0.389	0.498	0.635	0.401	0.552	0.450	0.452	0.447
33	0.454	0.424	0.524	0.456	0.619	0.320	0.612	0.585	0.429	0.570	0.489	0.496	0.502	0.444	0.504	0.459	0.356	0.594	0.428	0.440	0.559	0.635	0.463	0.616	0.481
34	0.589	0.432	0.533	0.555	0.428	0.462	0.421	0.421	0.502	0.369	0.671	0.617	0.584	0.498	0.491	0.611	0.609	0.471	0.528	0.545	0.367	0.383	0.429	0.509	0.458
35	0.572	0.419	0.418	0.422	0.548	0.379	0.357	0.579	0.341	0.564	0.735	0.561	0.584	0.449	0.412	0.501	0.457	0.514	0.530	0.513	0.514	0.549	0.536	0.504	0.585
36	0.400	0.475	0.516	0.500	0.537	0.487	0.547	0.465	0.377	0.430	0.567	0.506	0.439	0.635	0.541	0.575	0.292	0.595	0.432	0.584	0.407	0.379	0.357	0.416	0.447
37	0.622	0.462	0.514	0.483	0.406	0.382	0.517	0.567	0.549	0.487	0.457	0.484	0.417	0.569	0.462	0.471	0.421	0.580	0.504	0.619	0.563	0.501	0.356	0.546	0.447
38	0.407	0.515	0.437	0.451	0.520	0.553	0.525	0.557	0.424	0.642	0.459	0.482	0.566	0.452	0.563	0.479	0.491	0.627	0.531	0.265	0.481	0.453	0.545	0.537	0.283
39	0.491	0.508	0.581	0.472	0.559	0.411	0.444	0.521	0.570	0.313	0.499	0.459	0.411	0.435	0.478	0.467	0.597	0.470	0.459	0.377	0.528	0.516	0.406	0.474	0.513
40	0.513	0.441	0.468	0.365	0.602	0.633	0.533	0.437	0.543	0.522	0.454	0.577	0.509	0.446	0.339	0.517	0.479	0.468	0.345	0.534	0.529	0.552	0.599	0.521	0.349
Mean	0.501	0.483	0.489	0.488	0.502	0.488	0.486	0.503	0.484	0.500	0.492	0.513	0.484	0.506	0.495	0.481	0.469	0.506	0.505	0.516	0.492	0.494	0.499	0.516	0.495
Std. Dev	0.079	0.068	0.083	0.084	0.090	0.093	0.061	0.069	0.091	0.108	0.086	0.082	0.082	0.083	0.087	0.077	0.099	0.086	0.086	0.089	0.070	0.101	0.082	0.081	0.093

Table 4.4. Normal Random Number Generating with mean = 0.4987 and standard deviation = 0.0866

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	0.456	0.549	0.492	0.331	0.508	0.579	0.330	0.576	0.482	0.686	0.591	0.450	0.559	0.427	0.479	0.491	0.514	0.520	0.429	0.521	0.671	0.502	0.683	0.388	0.456
2	0.457	0.538	0.481	0.522	0.341	0.381	0.578	0.439	0.489	0.443	0.525	0.488	0.457	0.487	0.571	0.446	0.601	0.489	0.620	0.438	0.292	0.519	0.373	0.488	0.286
3	0.622	0.358	0.550	0.632	0.558	0.498	0.509	0.570	0.543	0.601	0.510	0.455	0.557	0.546	0.630	0.522	0.462	0.585	0.464	0.461	0.439	0.516	0.554	0.485	0.540
4	0.418	0.541	0.537	0.488	0.541	0.612	0.354	0.413	0.456	0.504	0.606	0.572	0.445	0.466	0.603	0.408	0.517	0.679	0.488	0.526	0.391	0.578	0.559	0.510	0.478
5	0.517	0.540	0.516	0.509	0.636	0.571	0.681	0.372	0.558	0.330	0.556	0.398	0.499	0.400	0.427	0.569	0.461	0.505	0.453	0.603	0.345	0.467	0.536	0.576	0.390
6	0.383	0.578	0.588	0.489	0.456	0.560	0.439	0.529	0.387	0.524	0.368	0.370	0.432	0.451	0.524	0.529	0.493	0.541	0.435	0.459	0.542	0.574	0.435	0.376	0.556
7	0.494	0.566	0.621	0.521	0.483	0.412	0.509	0.597	0.321	0.423	0.455	0.688	0.431	0.485	0.514	0.485	0.579	0.467	0.536	0.520	0.530	0.451	0.570	0.571	0.458
8	0.546	0.662	0.604	0.530	0.457	0.412	0.364	0.348	0.610	0.375	0.479	0.463	0.641	0.471	0.312	0.454	0.415	0.627	0.440	0.647	0.499	0.664	0.544	0.537	0.444
9	0.366	0.682	0.430	0.449	0.423	0.488	0.609	0.402	0.472	0.460	0.448	0.368	0.521	0.711	0.463	0.359	0.676	0.302	0.454	0.429	0.571	0.366	0.503	0.565	0.499
10	0.490	0.476	0.588	0.587	0.563	0.307	0.524	0.408	0.512	0.468	0.542	0.556	0.412	0.504	0.431	0.375	0.486	0.414	0.571	0.723	0.578	0.484	0.535	0.662	0.449
11	0.524	0.614	0.364	0.636	0.480	0.477	0.744	0.638	0.575	0.567	0.400	0.416	0.363	0.331	0.457	0.541	0.545	0.483	0.591	0.379	0.566	0.548	0.501	0.444	0.545
12	0.510	0.513	0.576	0.614	0.487	0.382	0.579	0.469	0.490	0.532	0.633	0.526	0.443	0.561	0.549	0.520	0.451	0.543	0.500	0.622	0.562	0.497	0.479	0.375	0.553
13	0.503	0.416	0.486	0.493	0.504	0.544	0.457	0.556	0.423	0.533	0.270	0.446	0.555	0.572	0.396	0.522	0.407	0.522	0.587	0.374	0.605	0.414	0.406	0.515	0.447
14	0.564	0.507	0.483	0.465	0.476	0.558	0.552	0.574	0.651	0.320	0.411	0.502	0.321	0.425	0.415	0.575	0.374	0.423	0.460	0.419	0.537	0.625	0.431	0.307	0.484
15	0.511	0.384	0.555	0.356	0.665	0.483	0.390	0.430	0.529	0.595	0.488	0.360	0.454	0.374	0.502	0.532	0.523	0.502	0.613	0.666	0.420	0.528	0.424	0.612	0.487
16	0.588	0.475	0.364	0.566	0.526	0.526	0.610	0.576	0.432	0.580	0.609	0.556	0.517	0.485	0.415	0.526	0.692	0.394	0.355	0.564	0.649	0.580	0.441	0.580	0.459
17	0.540	0.435	0.467	0.320	0.652	0.673	0.568	0.522	0.433	0.574	0.471	0.525	0.562	0.549	0.665	0.415	0.413	0.600	0.548	0.491	0.276	0.525	0.579	0.625	0.416
18	0.544	0.450	0.415	0.459	0.788	0.633	0.534	0.596	0.408	0.490	0.417	0.576	0.459	0.315	0.406	0.401	0.447	0.471	0.514	0.451	0.445	0.565	0.252	0.466	0.386
19	0.493	0.524	0.438	0.602	0.494	0.511	0.496	0.361	0.562	0.586	0.539	0.379	0.322	0.403	0.537	0.453	0.443	0.478	0.542	0.482	0.616	0.391	0.482	0.518	0.601
20	0.424	0.648	0.463	0.309	0.503	0.579	0.451	0.498	0.501	0.682	0.516	0.470	0.495	0.579	0.628	0.612	0.509	0.509	0.594	0.435	0.521	0.389	0.533	0.406	0.461
21	0.383	0.522	0.383	0.578	0.273	0.485	0.354	0.671	0.455	0.451	0.483	0.670	0.435	0.432	0.456	0.430	0.540	0.616	0.485	0.538	0.448	0.562	0.432	0.392	0.427
22	0.521	0.557	0.395	0.372	0.425	0.533	0.620	0.494	0.536	0.566	0.406	0.454	0.506	0.446	0.545	0.530	0.448	0.433	0.538	0.538	0.482	0.572	0.387	0.515	0.510
23	0.599	0.420	0.478	0.404	0.531	0.491	0.479	0.470	0.537	0.380	0.467	0.506	0.570	0.640	0.505	0.503	0.560	0.625	0.403	0.398	0.432	0.558	0.441	0.316	0.540
24	0.509	0.511	0.459	0.541	0.684	0.500	0.419	0.465	0.547	0.472	0.604	0.548	0.496	0.521	0.606	0.484	0.463	0.624	0.588	0.462	0.515	0.474	0.549	0.516	0.573
25	0.481	0.478	0.355	0.391	0.397	0.571	0.393	0.561	0.541	0.558	0.476	0.536	0.409	0.417	0.649	0.450	0.518	0.372	0.360	0.434	0.464	0.537	0.299	0.450	0.579
26	0.521	0.557	0.466	0.354	0.572	0.538	0.545	0.367	0.416	0.360	0.571	0.397	0.638	0.485	0.542	0.342	0.339	0.613	0.677	0.422	0.557	0.406	0.572	0.487	0.336
27	0.421	0.596	0.549	0.566	0.493	0.352	0.576	0.673	0.652	0.510	0.498	0.597	0.298	0.647	0.563	0.441	0.464	0.444	0.400	0.441	0.386	0.568	0.470	0.490	0.577
28	0.310	0.581	0.367	0.369	0.598	0.515	0.535	0.557	0.444	0.432	0.455	0.609	0.472	0.457	0.388	0.493	0.445	0.431	0.647	0.423	0.549	0.353	0.523	0.511	0.469
29	0.481	0.577	0.426	0.506	0.199	0.596	0.395	0.506	0.550	0.489	0.546	0.500	0.397	0.390	0.585	0.574	0.461	0.339	0.333	0.504	0.426	0.400	0.477	0.458	0.429
30	0.415	0.448	0.420	0.466	0.487	0.485	0.588	0.428	0.475	0.484	0.419	0.418	0.539	0.579	0.577	0.467	0.375	0.447	0.515	0.596	0.457	0.471	0.425	0.610	0.425
31	0.502	0.441	0.435	0.493	0.518	0.466	0.637	0.607	0.493	0.571	0.545	0.641	0.459	0.404	0.519	0.518	0.422	0.548	0.524	0.533	0.331	0.604	0.542	0.624	0.549
32	0.645	0.467	0.432	0.418	0.551	0.501	0.482	0.416	0.549	0.364	0.578	0.474	0.550	0.551	0.475	0.433	0.577	0.514	0.455	0.459	0.472	0.588	0.375	0.526	0.801
33	0.551	0.522	0.697	0.762	0.417	0.624	0.590	0.463	0.666	0.542	0.452	0.548	0.364	0.618	0.544	0.449	0.479	0.570	0.547	0.442	0.432	0.536	0.383	0.375	0.570
34	0.502	0.511	0.481	0.574	0.602	0.518	0.440	0.445	0.637	0.495	0.598	0.460	0.467	0.475	0.447	0.625	0.448	0.300	0.582	0.513	0.485	0.516	0.519	0.428	0.385
35	0.382	0.516	0.447	0.534	0.450	0.452	0.572	0.588	0.595	0.618	0.493	0.574	0.416	0.444	0.550	0.706	0.572	0.487	0.495	0.447	0.616	0.359	0.318	0.603	0.700
36	0.526	0.452	0.541	0.690	0.332	0.450	0.669	0.467	0.606	0.642	0.438	0.507	0.534	0.459	0.440	0.485	0.498	0.391	0.516	0.539	0.473	0.587	0.525	0.547	0.363
37	0.596	0.434	0.375	0.555	0.534	0.475	0.472	0.453	0.653	0.681	0.597	0.657	0.578	0.466	0.489	0.486	0.616	0.484	0.518	0.664	0.516	0.588	0.490	0.511	0.570
38	0.320	0.524	0.521	0.536	0.592	0.470	0.457	0.585	0.449	0.439	0.412	0.539	0.481	0.510	0.576	0.499	0.498	0.529	0.364	0.531	0.556	0.597	0.519	0.503	0.491
39	0.553	0.454	0.509	0.498	0.420	0.481	0.425	0.521	0.505	0.569	0.402	0.507	0.505	0.564	0.507	0.513	0.571	0.518	0.499	0.593	0.602	0.468	0.273	0.509	0.438
40	0.409	0.579	0.629	0.453	0.422	0.423	0.360	0.558	0.532	0.553	0.392	0.482	0.531	0.568	0.576	0.542	0.506	0.606	0.434	0.451	0.635	0.608	0.515	0.419	0.578
Mean	0.489	0.515	0.485	0.498	0.501	0.503	0.507	0.504	0.517	0.511	0.492	0.505	0.477	0.490	0.512	0.493	0.495	0.499	0.502	0.503	0.497	0.513	0.471	0.495	0.493
Std. Dev	0.079	0.074	0.083	0.103	0.111	0.078	0.101	0.087	0.080	0.095	0.081	0.084	0.081	0.087	0.080	0.073	0.077	0.091	0.083	0.085	0.096	0.080	0.091	0.086	0.096

Table 4.5. Normal Random Number Generating with mean = 0.5021 and standard deviation = 0.0847

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	0.475	0.380	0.683	0.586	0.612	0.519	0.447	0.420	0.492	0.468	0.479	0.618	0.508	0.574	0.367	0.435	0.633	0.549	0.420	0.486	0.557	0.393	0.637	0.439	0.462
2	0.394	0.430	0.620	0.512	0.640	0.518	0.420	0.628	0.511	0.521	0.553	0.498	0.522	0.398	0.621	0.417	0.668	0.414	0.422	0.366	0.541	0.608	0.384	0.487	0.615
3	0.520	0.374	0.608	0.595	0.520	0.499	0.599	0.403	0.644	0.651	0.394	0.480	0.574	0.395	0.635	0.404	0.576	0.379	0.467	0.432	0.417	0.515	0.555	0.400	0.511
4	0.606	0.470	0.509	0.488	0.512	0.398	0.576	0.466	0.458	0.301	0.543	0.502	0.328	0.479	0.445	0.291	0.665	0.363	0.659	0.453	0.592	0.400	0.554	0.434	0.564
5	0.599	0.497	0.500	0.435	0.654	0.520	0.356	0.391	0.434	0.501	0.581	0.346	0.443	0.484	0.606	0.401	0.496	0.463	0.348	0.435	0.392	0.663	0.575	0.674	0.380
6	0.644	0.502	0.538	0.589	0.496	0.512	0.606	0.632	0.438	0.490	0.428	0.443	0.513	0.584	0.558	0.555	0.501	0.367	0.488	0.391	0.555	0.363	0.559	0.517	0.525
7	0.319	0.473	0.498	0.452	0.445	0.562	0.483	0.502	0.549	0.582	0.531	0.615	0.512	0.584	0.577	0.567	0.627	0.395	0.531	0.490	0.377	0.636	0.581	0.448	0.428
8	0.481	0.682	0.412	0.544	0.575	0.439	0.406	0.527	0.607	0.603	0.544	0.514	0.494	0.476	0.409	0.600	0.444	0.352	0.522	0.591	0.593	0.380	0.428	0.539	0.589
9	0.591	0.355	0.353	0.545	0.499	0.551	0.344	0.581	0.381	0.636	0.581	0.464	0.480	0.542	0.605	0.463	0.514	0.442	0.629	0.445	0.623	0.416	0.658	0.572	0.410
10	0.410	0.439	0.569	0.474	0.586	0.518	0.432	0.662	0.580	0.349	0.481	0.450	0.622	0.579	0.464	0.395	0.408	0.475	0.360	0.491	0.521	0.447	0.565	0.496	0.530
11	0.443	0.286	0.537	0.463	0.536	0.509	0.539	0.495	0.632	0.567	0.519	0.405	0.570	0.436	0.604	0.345	0.498	0.588	0.524	0.494	0.573	0.442	0.457	0.447	0.382
12	0.360	0.620	0.551	0.387	0.621	0.572	0.576	0.415	0.445	0.530	0.465	0.604	0.389	0.439	0.368	0.460	0.617	0.561	0.415	0.574	0.525	0.594	0.435	0.432	0.496
13	0.347	0.394	0.518	0.665	0.490	0.650	0.494	0.453	0.507	0.562	0.542	0.705	0.461	0.475	0.425	0.469	0.527	0.488	0.533	0.480	0.376	0.472	0.521	0.639	0.333
14	0.419	0.446	0.415	0.453	0.420	0.391	0.496	0.570	0.431	0.540	0.631	0.576	0.478	0.542	0.750	0.581	0.506	0.487	0.558	0.707	0.358	0.607	0.682	0.396	0.345
15	0.436	0.563	0.603	0.507	0.372	0.398	0.518	0.572	0.558	0.489	0.487	0.492	0.422	0.357	0.465	0.447	0.436	0.425	0.429	0.302	0.577	0.426	0.660	0.508	0.640
16	0.324	0.539	0.474	0.481	0.287	0.546	0.471	0.542	0.520	0.638	0.415	0.429	0.483	0.600	0.465	0.585	0.341	0.609	0.482	0.500	0.590	0.460	0.565	0.609	0.451
17	0.453	0.573	0.430	0.735	0.509	0.599	0.577	0.377	0.504	0.538	0.424	0.493	0.512	0.660	0.556	0.525	0.453	0.584	0.456	0.440	0.522	0.530	0.594	0.458	0.544
18	0.466	0.549	0.432	0.604	0.525	0.427	0.459	0.384	0.415	0.497	0.561	0.479	0.420	0.501	0.474	0.574	0.363	0.453	0.394	0.490	0.464	0.348	0.363	0.518	0.544
19	0.511	0.386	0.464	0.573	0.499	0.322	0.695	0.488	0.475	0.498	0.632	0.467	0.570	0.393	0.356	0.595	0.588	0.640	0.533	0.610	0.427	0.545	0.541	0.590	0.665
20	0.470	0.407	0.462	0.611	0.517	0.425	0.562	0.448	0.560	0.496	0.448	0.572	0.486	0.502	0.504	0.552	0.499	0.420	0.535	0.530	0.454	0.559	0.438	0.508	0.509
21	0.473	0.558	0.457	0.516	0.521	0.517	0.551	0.448	0.499	0.360	0.431	0.476	0.559	0.623	0.575	0.523	0.597	0.567	0.489	0.474	0.404	0.647	0.557	0.617	0.508
22	0.469	0.527	0.571	0.545	0.623	0.536	0.419	0.573	0.583	0.537	0.585	0.529	0.437	0.514	0.574	0.485	0.594	0.621	0.540	0.396	0.437	0.702	0.552	0.436	0.476
23	0.611	0.422	0.543	0.479	0.507	0.418	0.572	0.430	0.416	0.516	0.519	0.566	0.526	0.605	0.479	0.534	0.574	0.529	0.529	0.465	0.530	0.465	0.550	0.476	0.358
24	0.493	0.480	0.450	0.399	0.407	0.429	0.620	0.490	0.563	0.554	0.537	0.520	0.395	0.588	0.537	0.455	0.551	0.443	0.693	0.436	0.420	0.507	0.520	0.632	0.586
25	0.485	0.511	0.608	0.605	0.385	0.538	0.439	0.481	0.603	0.486	0.716	0.365	0.690	0.531	0.650	0.568	0.565	0.483	0.428	0.600	0.654	0.412	0.323	0.587	0.504
26	0.457	0.546	0.354	0.476	0.516	0.510	0.475	0.626	0.403	0.569	0.452	0.502	0.569	0.437	0.537	0.492	0.524	0.559	0.531	0.454	0.554	0.497	0.490	0.535	0.502
27	0.664	0.512	0.546	0.392	0.579	0.455	0.389	0.391	0.533	0.610	0.435	0.554	0.407	0.463	0.507	0.443	0.494	0.346	0.324	0.465	0.482	0.318	0.423	0.451	0.440
28	0.572	0.424	0.490	0.563	0.375	0.509	0.612	0.422	0.352	0.658	0.601	0.487	0.624	0.611	0.455	0.430	0.472	0.430	0.489	0.503	0.471	0.388	0.383	0.579	0.468
29	0.697	0.656	0.503	0.565	0.449	0.422	0.587	0.486	0.507	0.391	0.475	0.363	0.477	0.538	0.524	0.647	0.445	0.529	0.582	0.452	0.456	0.495	0.406	0.608	0.498
30	0.446	0.540	0.446	0.536	0.543	0.426	0.515	0.412	0.584	0.551	0.382	0.367	0.382	0.558	0.498	0.534	0.490	0.469	0.427	0.592	0.537	0.446	0.432	0.444	0.391
31	0.638	0.506	0.454	0.534	0.482	0.587	0.318	0.381	0.586	0.482	0.593	0.433	0.464	0.422	0.632	0.506	0.655	0.401	0.471	0.508	0.604	0.447	0.451	0.562	0.452
32	0.366	0.569	0.570	0.446	0.471	0.635	0.542	0.320	0.509	0.438	0.393	0.522	0.523	0.326	0.741	0.587	0.500	0.521	0.451	0.500	0.366	0.418	0.551	0.427	0.318
33	0.545	0.572	0.567	0.560	0.486	0.444	0.544	0.548	0.437	0.561	0.467	0.449	0.441	0.496	0.348	0.422	0.626	0.563	0.470	0.493	0.358	0.464	0.427	0.494	0.516
34	0.575	0.447	0.538	0.544	0.464	0.486	0.601	0.472	0.548	0.694	0.381	0.671	0.549	0.583	0.511	0.504	0.440	0.358	0.570	0.406	0.459	0.574	0.488	0.391	0.415
35	0.659	0.423	0.557	0.589	0.433	0.509	0.420	0.534	0.539	0.612	0.409	0.482	0.480	0.575	0.639	0.485	0.644	0.464	0.490	0.507	0.485	0.369	0.680	0.393	0.487
36	0.493	0.592	0.635	0.270	0.554	0.653	0.600	0.330	0.560	0.515	0.550	0.572	0.544	0.459	0.580	0.542	0.396	0.437	0.651	0.485	0.634	0.557	0.456	0.416	0.521
37	0.457	0.400	0.525	0.538	0.505	0.549	0.453	0.597	0.421	0.461	0.510	0.603	0.340	0.444	0.516	0.650	0.533	0.533	0.463	0.403	0.480	0.490	0.509	0.420	0.478
38	0.556	0.371	0.549	0.622	0.605	0.637	0.439	0.338	0.550	0.480	0.355	0.462	0.408	0.524	0.596	0.465	0.539	0.483	0.403	0.443	0.515	0.461	0.576	0.594	0.540
39	0.468	0.559	0.654	0.357	0.522	0.515	0.357	0.457	0.634	0.409	0.669	0.347	0.623	0.411	0.584	0.624	0.411	0.458	0.553	0.551	0.426	0.473	0.566	0.428	0.548
40	0.563	0.553	0.472	0.504	0.505	0.629	0.614	0.419	0.519	0.506	0.520	0.425	0.517	0.545	0.491	0.550	0.710	0.514	0.491	0.587	0.441	0.409	0.492	0.505	0.528
Mean	0.499	0.488	0.517	0.518	0.506	0.507	0.503	0.478	0.512	0.521	0.505	0.496	0.494	0.506	0.531	0.503	0.528	0.479	0.494	0.486	0.494	0.484	0.515	0.503	0.487
Std. Dev	0.097	0.088	0.077	0.088	0.079	0.079	0.091	0.089	0.074	0.085	0.085	0.085	0.080	0.080	0.096	0.082	0.090	0.080	0.083	0.075	0.083	0.093	0.089	0.079	0.082

Table 4.6. Demand Generation using Monte Carlo Simulation

Node ID	Normal RN		Generating the Nodal Demands (in CMD)			
	Mean	Std. Dev.	Average	Std. Dev.	Maximum	Minimum
1	-	-	-14,300	-	-17,122	-11,474
2	0.5019	0.0830	600	200	745	423
3	0.5019	0.0830	1,000	200	1,145	823
4	0.5019	0.0830	900	200	1,045	723
5	0.5019	0.0830	1,200	300	1,417	935
6	0.4979	0.0834	900	200	1,077	742
7	0.5019	0.0830	800	200	945	623
8	0.4979	0.0834	800	200	977	642
9	0.4979	0.0834	1,200	300	1,465	963
10	0.4955	0.0847	1,200	300	1,425	1,001
11	0.4979	0.0834	600	200	777	442
12	0.4955	0.0847	800	200	950	667
13	0.4987	0.0866	1,200	300	1,453	947
14	0.4987	0.0866	800	200	969	631
15	0.5021	0.0847	800	200	935	678
16	0.4955	0.0847	600	200	750	467
17	0.4955	0.0847	900	200	1,050	767

Note : CMD is cubic metre per day.

After generating the demand at various nodes, network performance is estimated under two possible conditions, viz.,

(i) Normal condition : when all pipes in the water distribution network are fully operational and then all average nodal demands.

(ii) Abnormal conditions :

(A). When supply = demand

1. Average demand during all the fourth demand patterns with pipeline failing one by one (21 conditions).
2. Maximum demand during all the fourth demand patterns with pipeline working and failing one by one (22 conditions).
3. Minimum demand during all the fourth demand patterns with pipeline working and failing one by one (22 conditions).

(B). When supply < demand

1. Supply is minimum and demand is maximum during all the fourth demand patterns with pipeline working and failing one by one (22 conditions).

2. Supply is minimum and demand is average during all the fourth demand patterns with pipeline working and failing one by one (22 conditions).

Before evaluating the performance under abnormal conditions, the network performance is evaluated under normal demand condition using EPANET to determine pressure head. Under the assumption that a network has 100% mechanical reliability, the pressure head available at various nodes as obtained from the hydraulic analysis are used to compute the discharges received at various nodes using equations (4.18.a) through (4.18.c) and is given Table 4.7.

Table 4.7. Network Performance Under Normal Condition

Node ID	1st demand pattern			2nd demand pattern			3rd demand pattern			4th demand pattern			Node Reliability
	Q_d	H_s	Q_{avl}	Q_d	H_s	Q_{avl}	Q_d	H_s	Q_{avl}	Q_d	H_s	Q_{avl}	
2	600	30.25	600	360	34.38	360	420	33.51	420	240	35.76	240	1.00
3	1,000	26.42	1,000	600	32.28	600	700	31.05	700	400	34.24	400	1.00
4	900	23.13	900	540	30.39	540	630	28.87	630	360	32.82	360	1.00
5	1,200	19.08	1,200	720	28.21	720	840	26.30	840	480	31.27	480	1.00
6	900	14.80	673	540	25.32	540	630	23.11	630	360	28.85	360	0.91
7	800	24.82	800	480	29.82	480	560	28.77	560	320	31.50	320	1.00
8	800	23.35	800	480	29.87	480	560	28.50	560	320	32.05	320	1.00
9	1,200	19.44	1,200	720	28.96	720	840	26.96	840	480	32.15	480	1.00
10	1,200	15.41	991	720	26.17	720	840	23.91	840	480	29.78	480	0.94
11	600	28.57	600	360	31.89	360	420	31.20	420	240	33.01	240	1.00
12	800	23.58	800	480	29.95	480	560	28.62	560	320	32.09	320	1.00
13	1,200	17.70	1,200	720	26.45	720	840	24.61	840	480	29.38	480	1.00
14	800	13.08	372	480	24.04	480	560	21.74	560	320	27.72	320	0.80
15	800	26.51	800	480	32.32	480	560	31.10	560	320	34.26	320	1.00
16	600	21.09	600	360	29.60	360	420	27.81	420	240	32.45	240	1.00
17	900	17.10	900	540	27.44	540	630	25.27	630	360	30.90	360	1.00
Sum	14,300		13,436	8,580		8,580	10,010		10,010	5,720		5,720	0.98
Volume Reliability	0.9396			1.0000			1.0000			1.0000			

Note : Q_d and Q_{avl} in CMD (cubic metre per day) and H_s in metre.

From Table 4.7, it is observed that only 6th, 10th and 14th nodes satisfy a minimum of 91%, 94% and 80% of the daily demand, respectively and remaining nodes satisfied 100% of daily demand. The network is found to be able to supply 98% full demand without mechanical failure. Furthermore, it may be concluded that in a day 98% of daily total demand is satisfied when all the pipelines are working.

After evaluating under normal condition, with same procedure and same assumption that a network has 100% mechanical reliability, the performance of a network is continuously evaluated under abnormal conditions, i.e., when supply equal to demand and supply less than demand using random variable of Q_d as shown in Table 4.8, Table 4.9, appendix B and C. From Table 4.8, it is observed that the node with head below the minimum value are 5th, 6th, 9th, 10th, 14th and 17th under maximum demand with supply equal to or less than demand, 13th node under maximum demand with supply less than demand and 14th node under average demand with supply less than demand. And from Table 4.9, it is observed that the network can satisfy during daily demand if the accepted value for the discharge ratio is 0.65.

Table 4.8. Nodal Hydraulic Pressure under Normal and Abnormal Conditions

Node ID	When Supply = Demand			When Supply < Demand	
	When Av. Demand	When Max. Demand	When Min. Demand	When Max. Demand	When Av. Demand
2	27.95	24.45	31.01	20.86	26.17
3	24.34	19.87	28.24	16.28	22.56
4	21.20	15.89	25.80	12.30	19.42
5	17.68	11.33	23.10	7.74	15.90
6	14.13	7.17	20.01	3.58	12.35
7	22.49	18.41	26.03	14.82	20.71
8	21.40	16.49	25.63	12.90	19.62
9	18.04	11.35	23.66	7.76	16.26
10	14.73	7.61	20.73	4.02	12.95
11	28.23	25.88	30.13	22.29	26.45
12	24.11	20.14	27.34	16.56	22.33
13	18.34	12.87	22.84	9.28	16.55
14	12.26	4.93	18.41	1.34	10.48
15	26.74	23.04	29.74	19.45	24.96
16	21.83	16.57	26.13	12.98	20.05
17	17.76	11.40	23.00	7.81	15.98

Note : Node hydraulic pressure in metre.

Considering the length and the diameter of each pipe, the available of all pipes are calculated using equations (4.5) through (4.9) as shown in Table 4.10. The system state probability are estimated using equations (4.10) and (4.11) as shown in Table 4.11. From Table 4.11, it is observed that the probability occurrence of the entire system working except for one analysis is 88.21%. The probability occurrence for two or more pipeline failing is 11.79%.

Table 4.9. Nodal Flow under Normal and Abnormal Conditions

Node ID	Flow	When Supply = Demand															When Supply < Demand									
		When Average Demand					When Maximum Demand					When Minimum Demand					When Maximum Demand					When Average Demand				
		I	II	III	IV	Average	I	II	III	IV	Average	I	II	III	IV	Average	I	II	III	IV	Average	I	II	III	IV	Average
2	Initial Flow	600	360	420	240	405	745	447	521	298	503	423	254	296	169	286	745	447	521	298	503	600	360	420	240	405
	Q_{avl}	573	344	401	229	387	688	426	497	284	474	404	242	283	162	273	686	426	497	284	474	573	344	401	229	387
3	Initial Flow	1,000	600	700	400	675	1,145	687	801	458	773	823	494	576	329	556	1,145	687	801	458	773	1,000	600	700	400	675
	Q_{avl}	864	573	639	382	614	988	624	728	437	695	748	471	550	314	521	988	624	706	437	689	864	571	636	382	613
4	Initial Flow	900	540	630	360	608	1,045	627	731	418	705	723	434	506	289	488	1,045	627	731	418	705	900	540	630	360	608
	Q_{avl}	736	515	569	344	541	676	562	598	399	559	598	414	483	276	443	665	529	598	398	548	736	512	553	344	536
5	Initial Flow	1,200	720	840	480	810	1,417	850	992	567	956	935	561	654	374	631	1,417	850	992	567	956	1,200	720	840	480	810
	Q_{avl}	684	679	717	458	635	293	720	761	541	579	745	535	625	357	566	288	684	632	532	534	683	667	696	458	626
6	Initial Flow	900	540	630	360	608	1,077	646	754	431	727	742	445	519	297	501	1,077	646	754	431	727	900	540	630	360	608
	Q_{avl}	217	482	516	344	390	0	520	491	411	356	523	425	481	283	428	49	468	225	381	281	215	472	489	344	380
7	Initial Flow	800	480	560	320	540	945	567	661	378	638	623	374	436	249	421	945	567	661	378	638	800	480	560	320	540
	Q_{avl}	691	458	535	305	497	816	540	601	361	579	579	357	416	238	397	815	530	585	361	573	691	458	529	305	496
8	Initial Flow	800	480	560	320	540	977	586	684	391	659	642	385	449	257	433	977	586	684	391	659	800	480	560	320	540
	Q_{avl}	650	458	535	305	487	638	559	616	373	547	595	368	429	245	409	633	549	566	373	530	650	458	532	305	486
9	Initial Flow	1,200	720	840	480	810	1,465	879	1,026	586	989	963	578	674	385	650	1,465	879	1,026	586	989	1,200	720	840	480	810
	Q_{avl}	612	655	728	458	613	226	751	811	559	587	775	551	622	368	579	281	722	640	533	544	610	652	709	458	608
10	Initial Flow	1,200	720	840	480	810	1,425	855	997	570	962	1,001	601	701	400	676	1,425	855	997	570	962	1,200	720	840	480	810
	Q_{avl}	308	648	704	458	529	0	703	658	544	476	713	573	643	382	578	65	643	343	510	390	306	640	664	458	517
11	Initial Flow	600	360	420	240	405	777	466	544	311	524	442	265	309	177	298	777	466	544	311	524	600	360	420	240	405
	Q_{avl}	545	344	401	239	382	706	445	505	297	488	416	253	295	177	285	706	441	494	297	484	545	344	400	232	380
12	Initial Flow	800	480	560	320	540	950	570	665	380	641	667	400	467	267	451	950	570	665	380	641	800	480	560	320	540
	Q_{avl}	677	436	509	318	485	661	518	590	363	533	598	382	435	267	421	657	514	567	345	521	676	436	509	310	483
13	Initial Flow	1,200	720	840	480	810	1,453	872	1,017	581	981	947	568	663	379	639	1,453	872	1,017	581	981	1,200	720	840	480	810
	Q_{avl}	597	655	762	458	618	114	788	783	523	552	774	516	602	379	568	175	738	536	523	493	595	655	740	433	606
14	Initial Flow	800	480	560	320	540	969	581	678	388	654	631	379	442	252	426	969	581	678	388	654	800	480	560	320	540
	Q_{avl}	78	424	438	305	311	0	441	311	360	278	340	350	397	241	332	44	344	110	334	208	76	409	371	302	289
15	Initial Flow	800	480	560	320	540	935	561	655	374	631	678	407	474	271	457	935	561	655	374	631	800	480	560	320	540
	Q_{avl}	691	454	508	320	493	747	507	565	357	544	585	388	453	271	424	745	496	565	355	540	691	449	501	316	489
16	Initial Flow	600	360	420	240	405	750	450	525	300	506	467	280	327	187	316	750	450	525	300	506	600	360	420	240	405
	Q_{avl}	415	327	380	240	341	281	405	441	273	350	399	255	297	187	285	292	394	380	273	335	415	327	374	233	337
17	Initial Flow	900	540	630	360	608	1,050	630	735	420	709	767	460	537	307	518	1,050	630	735	420	709	900	540	630	360	608
	Q_{avl}	371	491	560	343	441	32	552	508	382	368	558	419	488	307	443	79	483	368	382	328	369	491	526	335	430
Total	Initial Flow	14,300	8,580	10,010	5,720	9,653	17,122	10,273	11,986	6,849	11,558	11,474	6,885	8,032	4,590	7,745	17,122	10,273	11,986	6,849	11,558	14,300	8,580	10,010	5,720	9,653
	Q_{avl}	8,708	7,943	8,901	5,507	7,765	6,866	9,062	9,464	6,463	7,964	9,351	6,501	7,500	4,453	6,951	7,169	8,584	7,813	6,317	7,471	8,696	7,885	8,631	5,444	7,664

Node flow in CMD (cubic metre per day)

Table 4.10. Working and Shutdown Times

Link ID	Length m	Diameter mm	Number of breaks (per km per year)	MTTF (yr-1)	MTTR (yr-1)	$Ai = \frac{MTTF}{MTTF + MTTR}$	$UAi = 1 - Ai$
1	2	3	4 = 2.5exp(0.04(t-0.1*(3)))	5 = (4)*(2)	6=9.6*((3)^0.4)/8760	7 = (5)/((5)+(6))	8 = 1 - (7)
Pipe 1	1400	350	1.68	0.4262	0.011413	0.9739	0.02608
Pipe 2	1700	350	1.68	0.3510	0.011413	0.9685	0.03149
Pipe 3	1000	300	2.05	0.4886	0.010730	0.9785	0.02149
Pipe 4	900	250	2.50	0.4444	0.009976	0.9780	0.02195
Pipe 5	1350	200	3.05	0.2426	0.009124	0.9638	0.03625
Pipe 6	900	300	2.05	0.5428	0.010730	0.9806	0.01938
Pipe 7	1100	250	2.50	0.3636	0.009976	0.9733	0.02670
Pipe 8	1400	200	3.05	0.2339	0.009124	0.9625	0.03754
Pipe 9	900	200	3.05	0.3639	0.009124	0.9755	0.02446
Pipe 10	1000	200	3.05	0.3275	0.009124	0.9729	0.02710
Pipe 11	1200	150	3.73	0.2234	0.008132	0.9649	0.03512
Pipe 12	1100	300	2.05	0.4441	0.010730	0.9764	0.02359
Pipe 13	800	200	3.05	0.4094	0.009124	0.9782	0.02180
Pipe 14	1400	200	3.05	0.2339	0.009124	0.9625	0.03754
Pipe 15	800	150	3.73	0.3352	0.008132	0.9763	0.02369
Pipe 16	1100	200	3.05	0.2977	0.009124	0.9703	0.02973
Pipe 17	1200	250	2.50	0.3333	0.009976	0.9709	0.02906
Pipe 18	800	200	3.05	0.4094	0.009124	0.9782	0.02180
Pipe 19	900	150	3.73	0.2979	0.008132	0.9734	0.02657
Pipe 20	1400	200	3.05	0.2339	0.009124	0.9625	0.03754
Pipe 21	1200	150	3.73	0.2234	0.008132	0.9649	0.03512

Table 4.11 System State Probability Under Pipe Failure Condition

No. of state	State	Probability of occurrence	State Probability
1	All pipeline are working simultaneously	0.5472	0.5472
2	1st pipeline is failing and all other working simultaneously	0.0147	0.5618
3	2nd pipeline is failing and all other working simultaneously	0.0178	0.5650
4	3rd pipeline is failing and all other working simultaneously	0.0120	0.5592
5	4th pipeline is failing and all other working simultaneously	0.0123	0.5595
6	5th pipeline is failing and all other working simultaneously	0.0206	0.5678
7	6th pipeline is failing and all other working simultaneously	0.0108	0.5580
8	7th pipeline is failing and all other working simultaneously	0.0150	0.5622
9	8th pipeline is failing and all other working simultaneously	0.0213	0.5685
10	9th pipeline is failing and all other working simultaneously	0.0137	0.5609
11	10th pipeline is failing and all other working simultaneously	0.0152	0.5624
12	11th pipeline is failing and all other working simultaneously	0.0199	0.5671
13	12th pipeline is failing and all other working simultaneously	0.0132	0.5604
14	13th pipeline is failing and all other working simultaneously	0.0122	0.5594
15	14th pipeline is failing and all other working simultaneously	0.0213	0.5685
16	15th pipeline is failing and all other working simultaneously	0.0133	0.5605
17	16th pipeline is failing and all other working simultaneously	0.0168	0.5640
18	17th pipeline is failing and all other working simultaneously	0.0164	0.5636
19	18th pipeline is failing and all other working simultaneously	0.0122	0.5594
20	19th pipeline is failing and all other working simultaneously	0.0149	0.5621
21	20th pipeline is failing and all other working simultaneously	0.0213	0.5685
22	21st pipeline is failing and all other working simultaneously	0.0199	0.5671

The hydraulic reliability is computed for each node using equation (4.19) as shown in appendix D. The overall system hydraulic reliability is estimated using equations (7.21) through (4.23) as shown in Table (4.12) and appendix E. The corresponding overall nodal hydraulic reliability versus nodes at normal and abnormal conditions are shown in Graph 4.1.

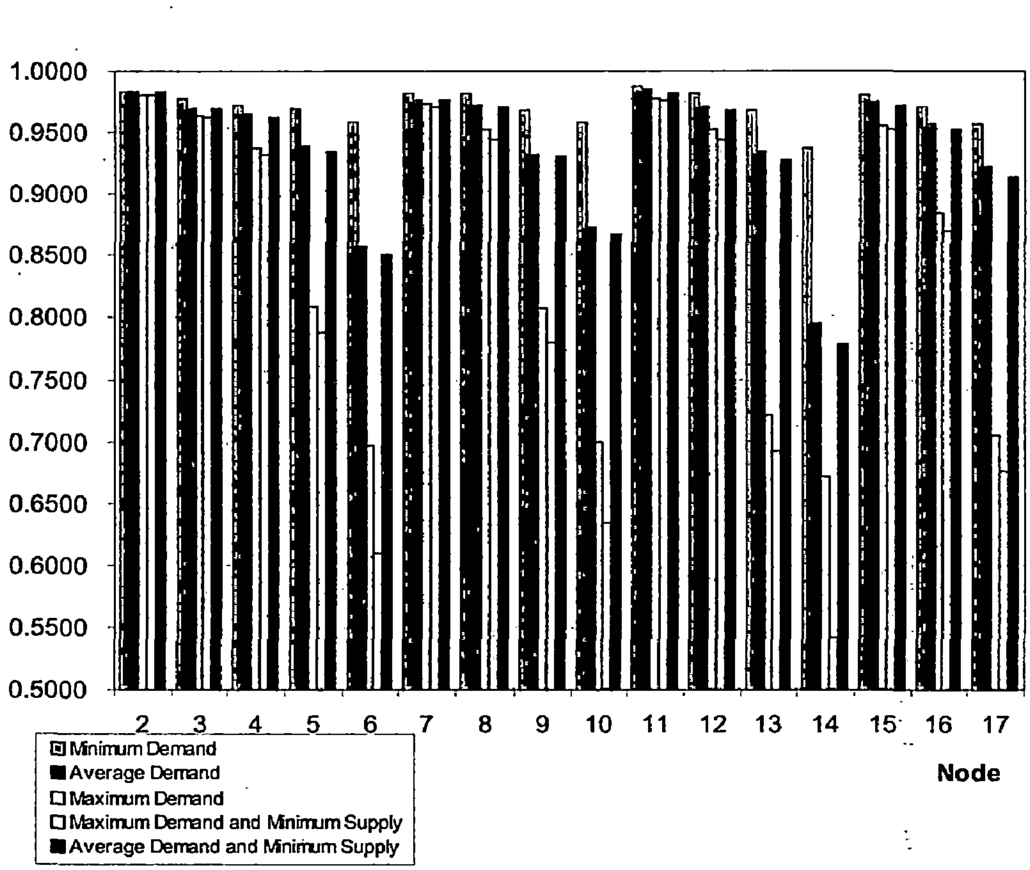
Next, the water quality reliability analysis is then performed under the different states and different demand patterns. The chlorine concentration at various nodes is obtained using water quality analysis by EPANET. Under assumption that a network has 100% mechanical reliability, the water quality reliability factor is computed for each node using equation (4.20) as shown in Table 4.13 and in appendix F. From Table 4.13, it is observed that the residual chlorine concentration levels at all nodes during daily demand was above the minimum desired level (0.2 mg/L), hence the nodal water quality reliability in the system is 1. The overall system quality reliability is estimated using equations (7.24) through (4.26) as shown in Table 4.14 and appendix G. The corresponding overall nodal quality reliability versus nodes at normal and abnormal conditions are shown in Graph 4.2.

Table 4.12. Overall System Hydraulic Reliability

Node ID	When Supply = Demand			When Supply < Demand	
	When Av. Demand	When Max. Demand	When Min. Demand	When Max. Demand	When Av. Demand
2	0.9834	0.9808	0.9834	0.9807	0.9834
3	0.9700	0.9645	0.9783	0.9622	0.9693
4	0.9657	0.9376	0.9719	0.9325	0.9630
5	0.9388	0.8089	0.9696	0.7877	0.9352
6	0.8571	0.6970	0.9588	0.6100	0.8506
7	0.9766	0.9734	0.9816	0.9702	0.9759
8	0.9717	0.9533	0.9814	0.9452	0.9714
9	0.9325	0.8073	0.9675	0.7791	0.9301
10	0.8722	0.6995	0.9591	0.6337	0.8666
11	0.9841	0.9785	0.9876	0.9759	0.9818
12	0.9705	0.9528	0.9815	0.9445	0.9683
13	0.9354	0.7214	0.9675	0.6919	0.9282
14	0.7948	0.6714	0.9373	0.5422	0.7780
15	0.9749	0.9562	0.9800	0.9535	0.9716
16	0.9567	0.8857	0.9708	0.8700	0.9525
17	0.9227	0.7046	0.9571	0.6762	0.9148
System Reliability	0.9364	0.8473	0.9708	0.8140	0.9320

As shown in Table 4.12, the minimum overall nodal hydraulic reliability is 0.5422 under maximum demand and minimum supply at node 14. From Table 4.14, it was observed that the minimum overall nodal quality reliability is 0.5503 under minimum demand condition also at node 14, the low value is perhaps because of the far distance of the node from source. Thus, the network is acceptable only when each demand node in network satisfied at least 54.22 per cent of the daily total demand at the node.

Graph 4.1. Overall Nodal Hydraulic Reliability



Furthermore, the link importance measure is estimated also under the different states and the different demand patterns using equation (4.27). The network effectiveness index is calculated for each node using equation (4.28) as shown in Table 4.15.

Thus, the overall system hydraulic reliability is 0.8140 under supply less than demand (maximum demand and minimum supply conditions) with the network effectiveness index is 0.707 and the overall system quality reliability is 0.8926 under minimum demand (supply equal than demand).

Next, reliability augmentation is analysed using software Surfer version 7.00, the contour map is drawn for illustrating the overall nodal hydraulic reliability under normal and abnormal conditions as shown in Figures 4.3 through 4.7. The contour map can be used to predict the components which are to be developed.

Table 4.13. Residual Chlorine Concentration under Normal and Abnormal Conditions

Node ID	When Supply = Demand															When Supply < Demand									
	When Average Demand					When Maximum Demand					When Minimum Demand					When Maximum Demand					When Average Demand				
	I	II	III	IV	Average	I	II	III	IV	Average	I	II	III	IV	Average	I	II	III	IV	Average	I	II	III	IV	Average
2	1.00	0.65	0.31	0.44	0.60	1.00	0.65	0.32	0.45	0.60	1.00	0.65	0.31	0.44	0.60	1.00	0.77	0.57	0.69	0.76	1.00	0.72	0.46	0.59	0.69
3	1.00	0.57	0.27	0.37	0.55	1.00	0.58	0.27	0.39	0.56	1.00	0.54	0.25	0.35	0.53	1.00	0.69	0.47	0.59	0.69	1.00	0.63	0.37	0.49	0.62
4	1.00	0.54	0.24	0.35	0.53	1.00	0.56	0.25	0.37	0.54	1.00	0.51	0.22	0.32	0.51	1.00	0.66	0.44	0.56	0.66	1.00	0.59	0.34	0.45	0.60
5	1.00	0.52	0.22	0.33	0.52	1.00	0.54	0.23	0.35	0.53	1.00	0.49	0.20	0.31	0.50	1.00	0.64	0.41	0.54	0.65	1.00	0.57	0.32	0.44	0.58
6	1.00	0.43	0.19	0.25	0.47	1.00	0.46	0.18	0.28	0.48	1.00	0.39	0.18	0.22	0.45	1.00	0.54	0.31	0.42	0.57	1.00	0.47	0.23	0.33	0.51
7	1.00	0.59	0.28	0.39	0.57	1.00	0.61	0.28	0.41	0.57	1.00	0.57	0.27	0.37	0.55	1.00	0.71	0.49	0.62	0.70	1.00	0.65	0.40	0.51	0.64
8	1.00	0.54	0.24	0.35	0.53	1.00	0.56	0.25	0.37	0.55	1.00	0.52	0.23	0.33	0.52	1.00	0.67	0.44	0.57	0.67	1.00	0.60	0.34	0.46	0.60
9	1.00	0.47	0.20	0.29	0.49	1.00	0.50	0.21	0.31	0.50	1.00	0.44	0.19	0.26	0.47	1.00	0.59	0.36	0.48	0.61	1.00	0.52	0.27	0.38	0.54
10	1.00	0.45	0.19	0.27	0.48	1.00	0.48	0.20	0.29	0.49	1.00	0.42	0.17	0.24	0.45	1.00	0.56	0.34	0.44	0.58	1.00	0.49	0.26	0.35	0.52
11	1.00	0.65	0.32	0.45	0.60	1.00	0.66	0.32	0.46	0.61	1.00	0.64	0.31	0.44	0.60	1.00	0.77	0.56	0.70	0.76	1.00	0.72	0.46	0.59	0.69
12	1.00	0.61	0.28	0.41	0.58	1.00	0.62	0.29	0.42	0.58	1.00	0.59	0.27	0.40	0.56	1.00	0.73	0.52	0.66	0.73	1.00	0.68	0.41	0.54	0.66
13	1.00	0.54	0.23	0.35	0.53	1.00	0.56	0.24	0.37	0.54	1.00	0.51	0.21	0.32	0.51	1.00	0.66	0.43	0.57	0.67	1.00	0.60	0.34	0.46	0.60
14	1.00	0.40	0.19	0.22	0.45	1.00	0.43	0.18	0.25	0.46	1.00	0.37	0.16	0.18	0.43	1.00	0.50	0.29	0.38	0.54	1.00	0.44	0.23	0.29	0.49
15	1.00	0.59	0.27	0.40	0.56	1.00	0.60	0.28	0.41	0.57	1.00	0.57	0.26	0.38	0.55	1.00	0.71	0.49	0.63	0.71	1.00	0.65	0.39	0.52	0.64
16	1.00	0.56	0.25	0.37	0.55	1.00	0.58	0.26	0.39	0.56	1.00	0.54	0.23	0.35	0.53	1.00	0.69	0.46	0.60	0.69	1.00	0.63	0.36	0.49	0.62
17	1.00	0.48	0.21	0.29	0.49	1.00	0.50	0.21	0.32	0.51	1.00	0.44	0.18	0.26	0.47	1.00	0.60	0.37	0.49	0.61	1.00	0.53	0.28	0.38	0.55

Residual Chlorine Concentration in mg/L

Table 4.14. Overall System Quality Reliability

Node ID	When Supply = Demand			When Supply < Demand	
	When Av. Demand	When Max. Demand	When Min. Demand	When Max. Demand	When Av. Demand
2	0.9958	0.9958	0.9917	0.9958	0.9958
3	0.9924	0.9908	0.9839	1.0000	1.0000
4	0.9931	0.9966	0.9839	1.0000	1.0000
5	1.0000	1.0000	0.7947	1.0000	1.0000
6	0.9332	0.7537	0.9232	1.0000	1.0000
7	0.9958	0.9928	0.9885	1.0000	0.9958
8	0.9885	0.9897	0.9928	1.0000	1.0000
9	0.9534	0.8047	0.9331	1.0000	1.0000
10	0.7849	0.8038	0.7579	1.0000	0.9957
11	0.9963	0.9925	0.9963	1.0000	0.9963
12	0.9928	0.9928	0.9893	1.0000	1.0000
13	1.0000	1.0000	0.8298	1.0000	1.0000
14	0.7385	0.6002	0.5503	1.0000	0.8313
15	0.9916	0.9916	0.9844	1.0000	0.9963
16	0.9963	0.9963	0.9891	1.0000	1.0000
17	0.8039	0.9768	0.7580	1.0000	0.9859
System Reliability	0.9431	0.9212	0.8926	0.9997	0.9864

Graph. 4.2. Overall Nodal Quality Reliability

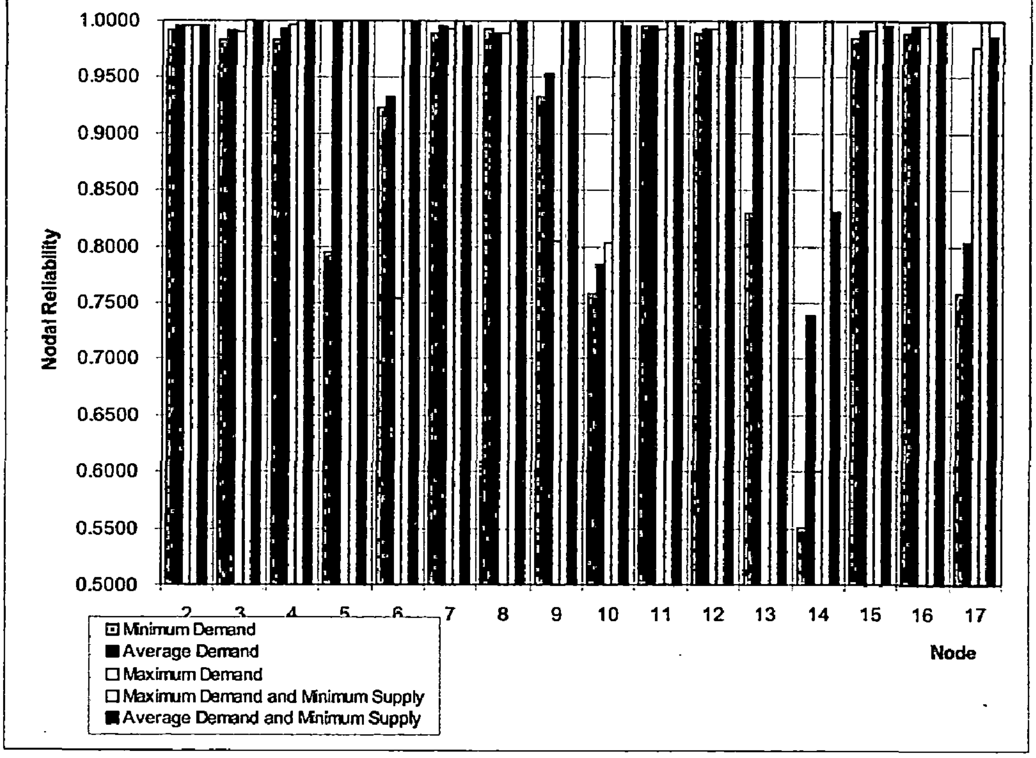


Table 4.15. Network Effectiveness Index for all conditions

Link ID	$Ai = \frac{MTTF}{MTTF + MTTR}$	When Supply = Demand						When Supply < Demand			
		When Av. Demand		When Max. Demand		When Min. Demand		When Max. Demand		When Av. Demand	
		LI_i	$LI_i \times A_i$	LI_i	$LI_i \times A_i$	LI_i	$LI_i \times A_i$	LI_i	$LI_i \times A_i$	LI_i	$LI_i \times A_i$
Pipe 1	0.9739	0.9084	0.8848	0.9449	0.9203	0.8362	0.8144	0.9677	0.9425	0.9249	0.9008
Pipe 2	0.9685	0.3211	0.3110	0.5092	0.4932	0.1699	0.1646	0.5653	0.5475	0.3620	0.3506
Pipe 3	0.9785	0.2037	0.1993	0.3839	0.3756	0.1248	0.1221	0.4615	0.4516	0.2473	0.2420
Pipe 4	0.9780	0.1430	0.1399	0.2660	0.2601	0.0708	0.0692	0.3503	0.3426	0.1659	0.1623
Pipe 5	0.9638	0.0535	0.0516	0.1192	0.1149	0.0069	0.0067	0.1567	0.1510	0.0554	0.0534
Pipe 6	0.9806	0.1587	0.1556	0.2486	0.2438	0.0334	0.0327	0.3545	0.3476	0.1697	0.1664
Pipe 7	0.9733	0.1208	0.1175	0.1767	0.1719	0.0073	0.0071	0.2606	0.2536	0.1228	0.1195
Pipe 8	0.9625	0.0709	0.0683	0.1435	0.1381	0.0012	0.0011	0.0012	0.0011	0.0713	0.0686
Pipe 9	0.9755	0.0377	0.0368	0.1178	0.1149	0.0000	0.0000	0.1974	0.1926	0.0381	0.0371
Pipe 10	0.9729	0.0626	0.0609	0.1348	0.1312	0.0199	0.0194	0.1733	0.1686	0.0682	0.0664
Pipe 11	0.9649	0.0171	0.0165	0.1094	0.1055	0.0000	0.0000	0.1246	0.1203	0.0175	0.0169
Pipe 12	0.9764	0.5902	0.5763	0.7225	0.7055	0.4320	0.4218	0.8247	0.8052	0.6455	0.6303
Pipe 13	0.9782	0.1340	0.1311	0.1987	0.1944	0.0168	0.0164	0.2949	0.2885	0.1385	0.1355
Pipe 14	0.9625	0.0896	0.0863	0.1477	0.1421	0.0006	0.0006	0.2131	0.2051	0.0899	0.0865
Pipe 15	0.9763	0.0226	0.0221	0.1140	0.1113	0.0000	0.0000	0.1144	0.1117	0.0230	0.0225
Pipe 16	0.9703	0.0221	0.0214	0.1151	0.1117	0.0043	0.0042	0.1340	0.1300	0.0239	0.0232
Pipe 17	0.9709	0.1633	0.1585	0.2859	0.2776	0.0772	0.0750	0.3840	0.3729	0.1917	0.1861
Pipe 18	0.9782	0.1197	0.1171	0.1896	0.1855	0.0189	0.0185	0.2765	0.2705	0.1240	0.1213
Pipe 19	0.9734	0.0155	0.0150	0.1122	0.1093	0.0000	0.0000	0.1281	0.1247	0.0157	0.0153
Pipe 20	0.9625	0.0706	0.0680	0.1562	0.1503	0.0320	0.0308	0.2039	0.1962	0.0795	0.0765
Pipe 21	0.9649	0.0330	0.0318	0.1048	0.1011	0.0000	0.0000	0.1330	0.1283	0.0332	0.0320
$NEI_{AVG} = 1 - \frac{\sum_{i=1}^{i=NP} LI_i A_i}{NP}$			0.8443		0.7544		0.9141		0.7070		0.8327

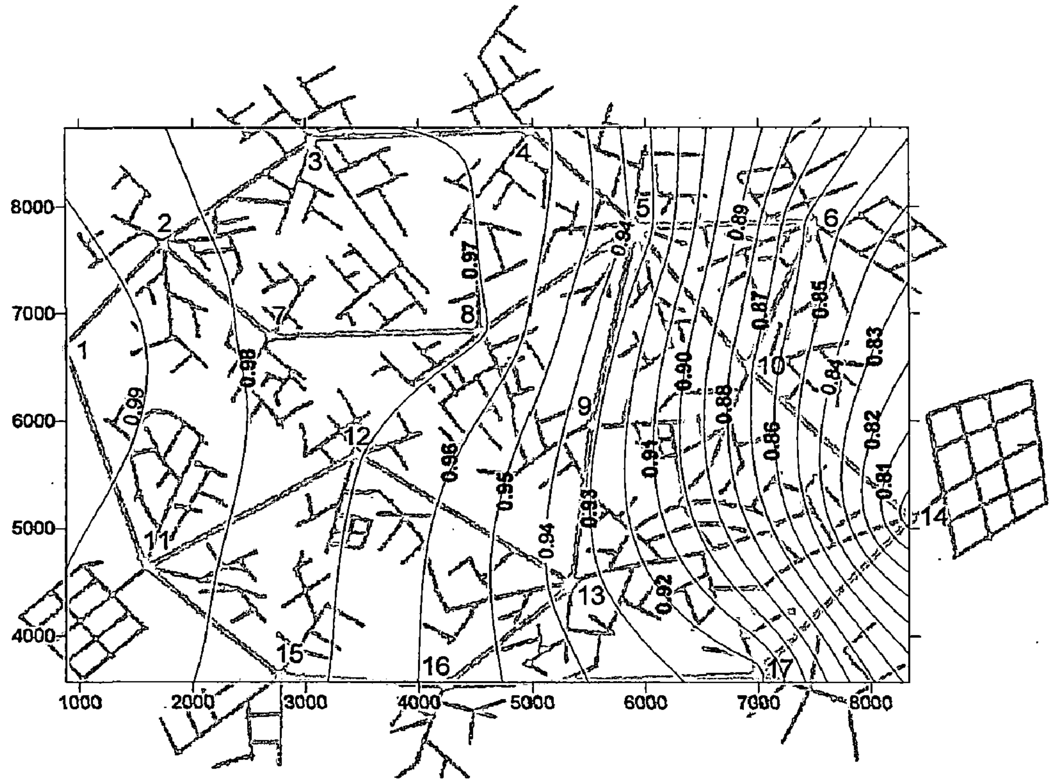


Figure 4.3. Contour Map under Average Demand

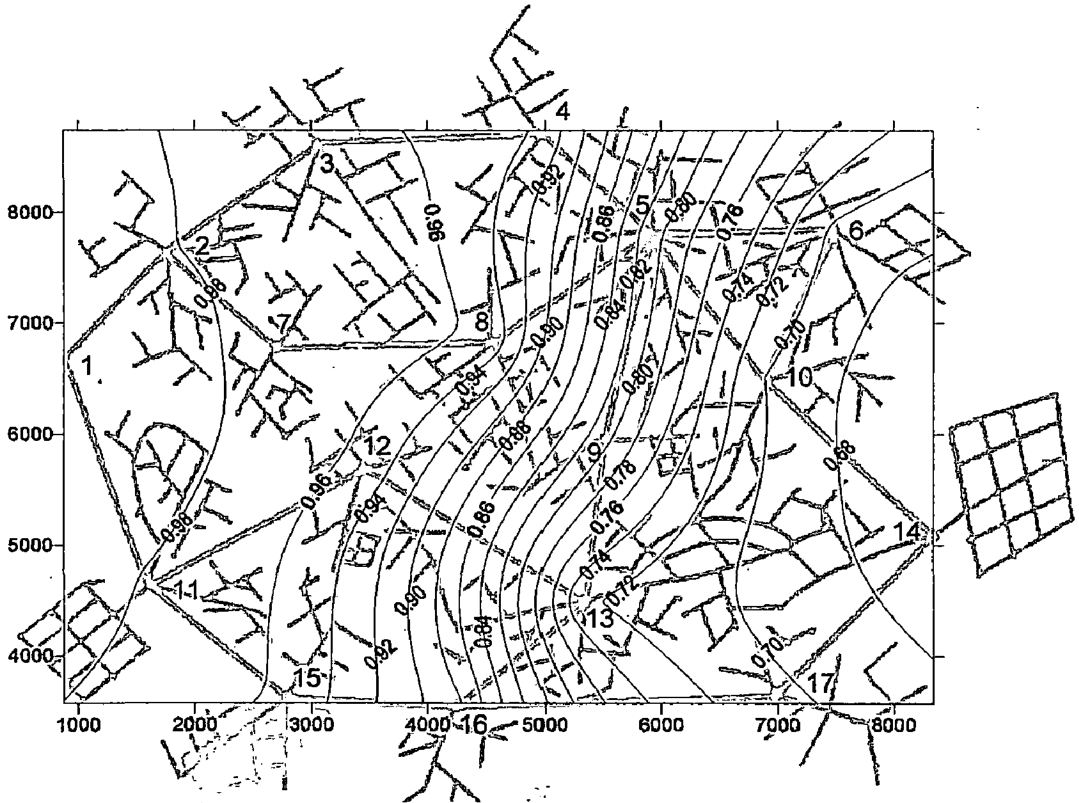


Figure 4.4 Contour Map under Maximum Demand

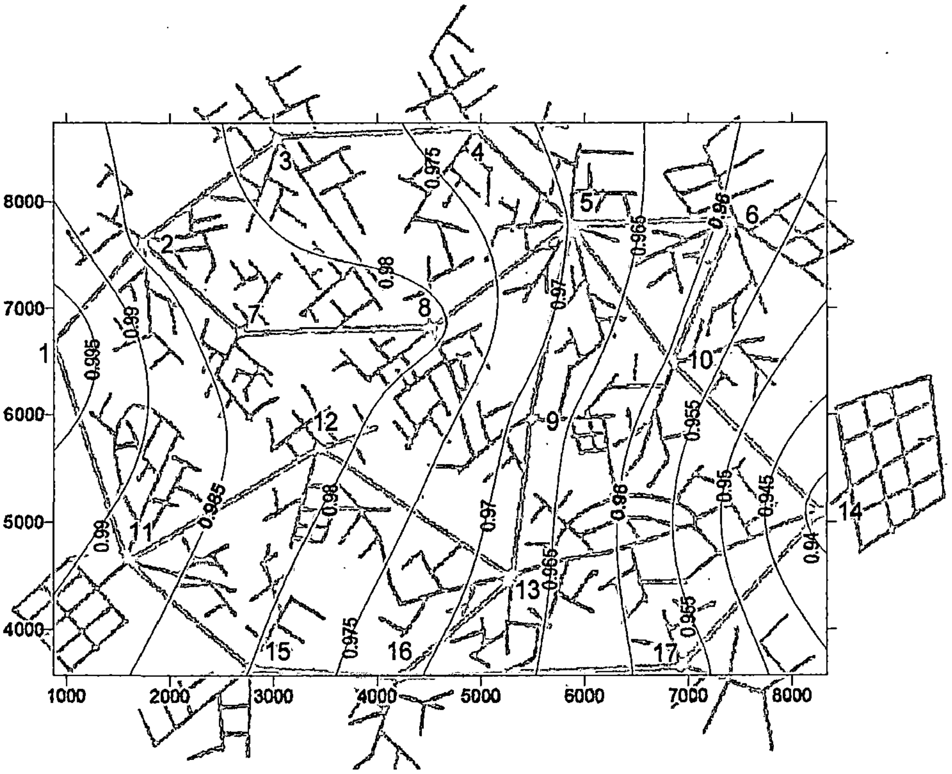


Figure 4.5. Contour Map under Minimum Demand

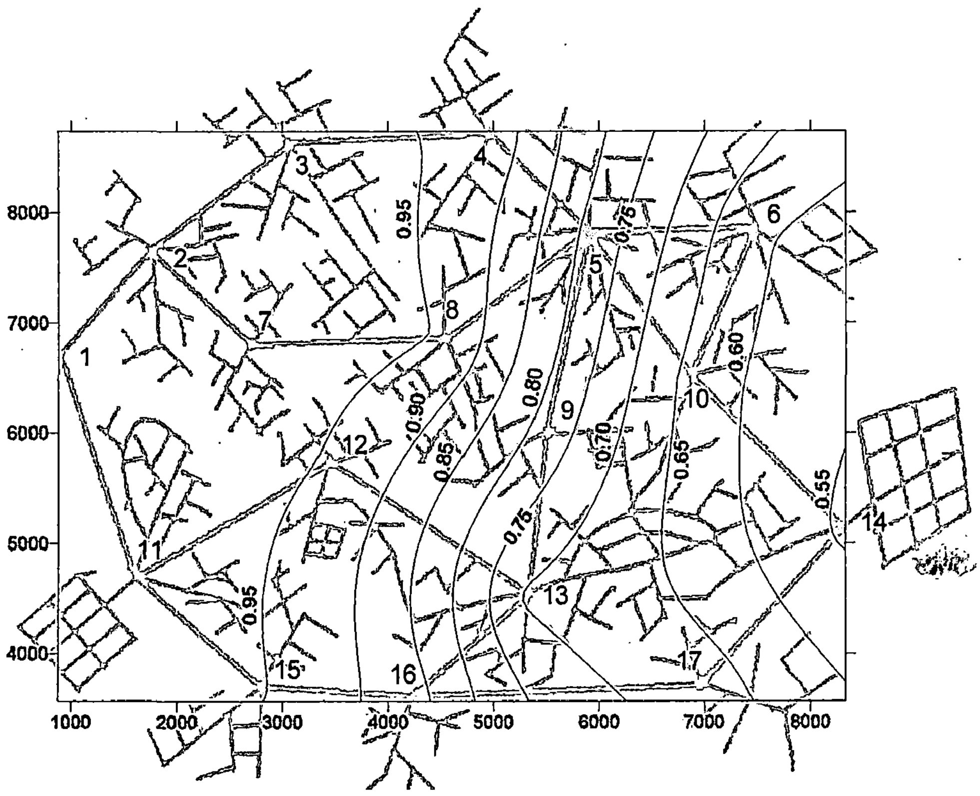


Figure 4.6. Contour Map under Maximum Demand and Minimum Supply

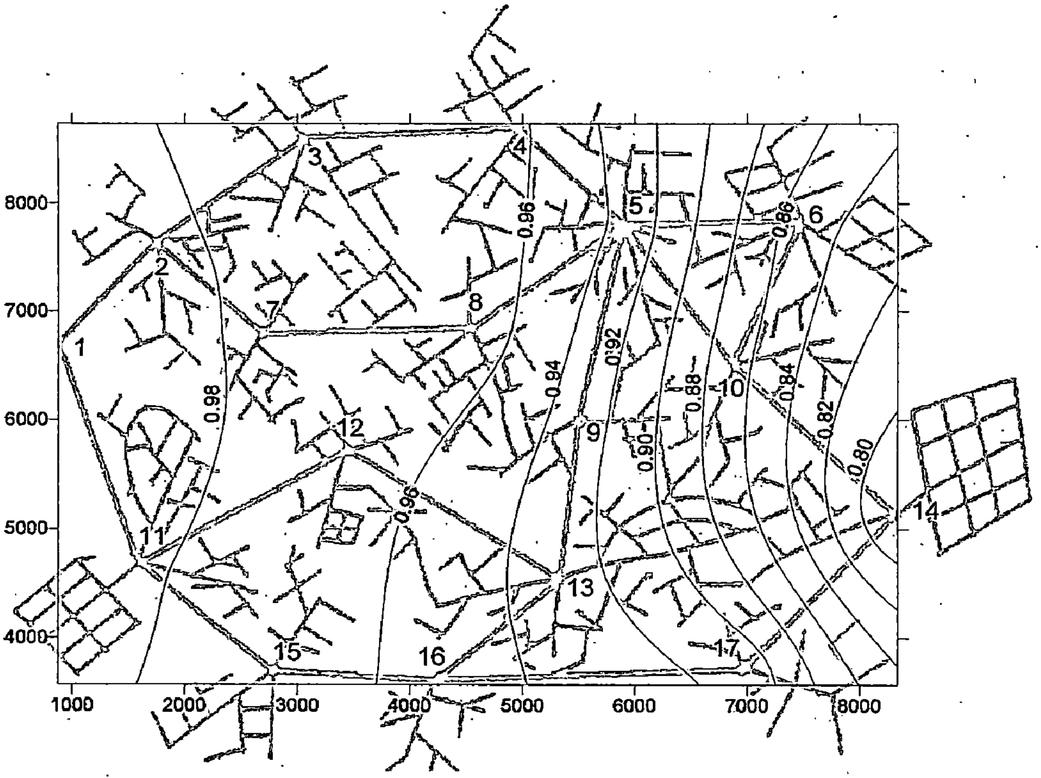


Figure 4.7. Contour Map under Average Demand and Minimum Supply

4.9. SUMMARY

The reliability of a water distribution network must be analysed to assess its capability to provide water of adequate, with requisite quantity and pressure. Most urban water distribution networks are designed to provide water service in terms of mechanical and hydraulic reliability. However, with the growing concern about water quality, its reliability analysis has become an equally important area. The failure of pipe has potential to affect the pressure head and chlorine concentration reaching the nodes of the water distribution network. A methodology has been presented here to evaluate mechanical, hydraulic and quality reliability under normal and abnormal conditions.

The availability of any pipe depends on the time for which it remains in the operating state. A component under non-operational state may be undergoing repair and maintenance work. Hence to carry out the availability analysis of any component, its mean time to failure and mean time to repair should estimate from the past experiences of operations and repairs. Once the probability of availability and non-availability is estimated. The performance of water distribution network based on failure of link components, effects of variations in demand and quality considerations using three parameters, namely : overall system hydraulic reliability, overall system quality reliability and network effectiveness index can be estimated.

The proposed methodology has been illustrated on an example water distribution network. In this example, three parameters mentioned above is compute under steady state flow conditions. The system reliability analysis has been carried out for two conditions, viz., (a) under normal condition; and (a) under abnormal conditions.

Simulation model is used to estimate the measure of performance of a water distribution network under those conditions. There are many simulation methods, Monte Carlo simulation, one of the most commonly used to estimate the measure of performance of a system is selected. Fundamental techniques for performing a Monte Carlo simulation has been explained and demonstrated. The procedure for performing a Monte Carlo simulation is mathematically simple to use, and therefore lends itself well to spreadsheet calculations. The result of the analysis can be used to provide demand node justification for reliability improvement to design new distribution system or extensions for the existing systems. Furthermore, with contour map of 'overall nodal hydraulic reliability area' using software Surfer version 7.0, the area of reliability improvement can be obtained easily.

CHAPTER 5

CONCLUSIONS

5.1. CONCLUSIONS

At a very basic level, a minimum amount of water is required for consumption on a daily basis for survival and therefore access to some form of water is essential for life. The first priority must be provide access to water supply for the whole population. However, water has much broader influences on health and well being. Issues such as the quantity and quality of the water supplied are important in determining the health of individuals and whole communities. Hence, there is a global desire to provide safe and adequate drinking water to the masses.

A drinking water supply scheme consists of the source, the treatment and the distribution. For quality improvement, measures of source protection and advanced treatment are not sufficient to ensure safety of water reaching to consumer. The water distribution network should also able be to maintain the high quality to make sure that quality at the consumer end is compliant with the standards. Water distribution networks are complex networks that require extensive planning and maintenance to ensure good water is delivered to all consumers in adequate quantity and pressure. Computer aided hydraulic simulations are very convenient and fast for this purpose.

It is known that, nodal demand often changes due to many factors such as new users or an increase the number of existing users. Because of their randomness or uncertainty, it is needed a tools to predict that may be occur in the future. Simulation method is one of the most commonly used to observe the behaviour of an existing or a proposed system to conditions that may be imposed on it or that may be occur in the future. The implication when applying simulation method to real system is that heuristic rules are needed to identify Monte Carlo iterations that will obviously meet the constraints.

Reliability analysis is essential to decision making for design, operation, maintenance and up-grading of a water distribution network. Three parameters are used to reliability measures, viz., overall system hydraulic reliability, overall system quality reliability and network effectiveness index. Overall system hydraulic reliability assess the probability of receiving the desired discharge at the nodes. Overall system quality reliability assess the probability of receiving the desired residual chlorine concentration at the nodes. Network effectiveness index estimated the probability of failure effects of the link components.

The minimum value of nodal hydraulic reliability is the value of the furthermost node from the source. That value is the minimum acceptable value for each demand in the node in a network satisfied.

The value of the overall system hydraulic reliability is high when demand nodes are minimum. It is reverse for overall system quality reliability-value of the system quality reliability is small when all demand nodes are in minimum conditions, because when a node has high pressure head, then the water temperature in the pipe going to that node also becomes higher resulting reduced disinfectant levels.

5.2. SCOPE FOR FURTHER STUDY

1. One can identify the areas of low reliability and carry out the analysis for reliability augmentation.
2. One can introduce reliability based design of water distribution networks, wherein, reliability and cost are compromised against each other.
3. There is a scope for further studies in water quality reliability assessment for different parameters of water quality.
4. One can carry out the effect of storages on the water quality at consumer's tap level.
5. There is a scope for performance evaluation under different types of pipe and appurtenance material.

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APPENDIX A

EPANET 2.0 Text Input File for Example Network Shown in Figure 3.4.

```
[TITLE]


[JUNCTIONS]
;ID          Elev         Demand       Pattern
 1           180          -14300       1            ;
 2           178          600                       ;
 3           179          1000                      ;
 4           180          900                       ;
 5           181          1200                      ;
 6           183          900                       ;
 7           182          800                       ;
 8           181          800                       ;
 9           180          1200                      ;
 10          182          1200                      ;
 11          181          600                       ;
 12          181          800                       ;
 13          183          1200                      ;
 14          184          800                       ;
 15          179          800                       ;
 16          180          600                       ;
 17          181          900                       ;
 18          180          0                         ;

[RESERVOIRS]
;ID          Head         Pattern

[TANKS]
;ID       Elevation   Init Level   Min Level   Max Level   Diameter   Min Vol   Vol Curve
 TANK     205         10           2           10          25         0                 ;
```

```
[PIPES]
;ID   Node1   Node2   Length   Diameter   Roughness   Minor Loss   Status
 1    1       2       1400     350        100         0            Open   ;
 2    2       3       1700     350        100         0            Open   ;
 3    3       4       1000     300        100         0            Open   ;
 4    4       5       900      250        100         0            Open   ;
 5    5       6       1350     200        100         0            Open   ;
 6    2       7       900      300        100         0            Open   ;
 7    7       8       1100     250        100         0            Open   ;
 8    8       5       1400     200        100         0            Open   ;
 9    5       9       900      200        100         0            Open   ;
 10   5       10      1000     200        100         0            Open   ;
 11   6       10      1200     150        100         0            Open   ;
 12   1       11      1100     300        100         0            Open   ;
 13   11      12      800      200        100         0            Open   ;
 14   12      13      1400     200        100         0            Open   ;
 15   13      9       800      150        100         0            Open   ;
 17   11      15      1200     250        100         0            Open   ;
 18   15      16      800      200        100         0            Open   ;
 19   16      13      900      150        100         0            Open   ;
 20   16      17      1400     200        100         0            Open   ;
 21   17      14      1200     150        100         0            Open   ;
 16   10      14      1100     200        100         0            Open   ;
 V    18      TANK    25       400        100         0            Open   ;
 H    18      1       80       400        100         0            Open   ;

[PUMPS]
;ID          Node1          Node2          Parameters

[VALVES]
;ID       Node1        Node2          Diameter       Type    Setting         Minor Loss

[TAGS]

[DEMANDS]
;Junction        Demand         Pattern        Category
```

```
[STATUS]
;ID              Status/Setting

[PATTERNS]
;ID              Multipliers
;DEMAND PATTERN
 1      1            1            1            1            1            1
 1      0.6          0.6          0.6          0.6          0.6          0.6
 1      0.7          0.7          0.7          0.7          0.7          0.7
 1      0.4          0.4          0.4          0.4          0.4          0.4
;CHLORINE PATTERN
 2      .7           .7           .7           .7           .7           .7
 2      .35          .35          .35          .35          .35          .35
 2      .5           .5           .5           .5           .5           .5
 2      .1           .1           .1           .1           .1           .1

[CURVES]
;ID              X-Value          Y-Value
;PUMP: PUMP CURVE
 1               7310             50

[CONTROLS]

[RULES]

[ENERGY]
 Global Efficiency        75
 Global Price             0
 Demand Charge            0

[EMITTERS]
;Junction         Coefficient

[QUALITY]
;Node             Init Qual
 1                1
 2                1
 3                1
```

```
4           1
5           1
6           1
7           1
8           1
9           1
10          1
11          1
12          1
13          1
14          1
15          1
16          1
17          1
18          1
TANK        1

[SOURCES]
;Node       Type        Quality     Pattern
1           CONCEN      1           2

[REACTIONS]
;Type       Pipe/Tank   Coefficient
Bulk        1           -1.2
Wall        1           -.2
Bulk        2           -1.2
Wall        2           -.2
Bulk        3           -1.2
Wall        3           -.2
Bulk        4           -1.2
Wall        4           -.2
Bulk        5           -1.2
Wall        5           -.2
Bulk        6           -1.2
Wall        6           -.2
Bulk        7           -1.2
Wall        7           -.2
Bulk        8           -1.2
```

```
Wall       8        -.2
Bulk       9        -1.2
Wall       9        -.2
Bulk       10       -1.2
Wall       10       -.2
Bulk       11       -1.2
Wall       11       -.2
Bulk       12       -1.2
Wall       12       -.2
Bulk       13       -1.2
Wall       13       -.2
Bulk       14       -1.2
Wall       14       -.2
Bulk       15       -1.2
Wall       15       -.2
Bulk       17       -1.2
Wall       17       -.2
Bulk       18       -1.2
Wall       18       -.2
Bulk       19       -1.2
Wall       19       -.2
Bulk       20       -1.2
Wall       20       -.2
Bulk       21       -1.2
Wall       21       -.2
Bulk       16       -1.2
Wall       16       -.2
Bulk       V        -1.2
Wall       V        -.2
Bulk       H        -1.2
Wall       H        -.2
Tank       TANK     0.4

[REACTIONS]
 Order Bulk        1
 Order Tank        1
 Order Wall        1
 Global Bulk       -1.2
```

```
 Global Wall            -.2
 Limiting Potential     0
 Roughness Correlation  0

[MIXING]
;Tank           Model

[TIMES]
 Duration               24
 Hydraulic Time step    1
 Quality Time step      0:05
 Pattern Time step      1:00
 Pattern Start          0
 Report Time step       1
 Report Start           0
 Start Clock Time       5 am
 Statistic              None

[REPORT]
 Status                 Full
 Summary                No
 Page                   0

[OPTIONS]
 Units                  CMD
 Head loss              H-W
 Specific Gravity       1
 Viscosity              1
 Trials                 100
 Accuracy               0.001
 Unbalanced             Continue 10
 Pattern                1
 Demand Multiplier      1.0
 Emitter Exponent       0.5
 Quality                Chlorine mg/L
 Diffusivity            1
 Tolerance              0.01
```

```
[COORDINATES]
;Node          X-Coord        Y-Coord
 1             877.93         6697.32
 2             1747.49        7658.86
 3             3051.84        8637.12
 4             4958.19        8737.46
 5             5903.01        7817.73
 6             7483.28        7859.53
 7             2700.67        6806.02
 8             4540.13        6847.83
 9             5510.03        5986.62
 10            6897.99        6513.38
 11            1605.35        4682.27
 12            3453.18        5702.34
 13            5326.09        4506.69
 14            8336.12        5108.70
 15            2784.28        3662.21
 16            4239.13        3570.23
 17            6989.97        3678.93
 18            -512.25        6703.79
 TANK          -512.25        8997.77

[VERTICES]
;Link          X-Coord        Y-Coord

[LABELS]
;X-Coord       Y-Coord      Label & Anchor Node

[BACKDROP]
 DIMENSIONS          0.00           0.00           10000.00       10000.00
 UNITS         None
 FILE
 OFFSET        0.00           0.00

[END]
```

Table B.1. Nodal Hydraulic Pressure Under Average Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	30.25	-193.44	33.13	32.57	32.04	30.39	31.52	31.19	30.86	30.85	30.58	30.27	19.45	28.31	29.04	29.79	30.50	27.48	28.35	30.18	29.20	29.99	19.66
	II	34.38	-52.47	35.50	35.28	35.08	34.43	34.87	34.74	34.62	34.61	34.51	34.39	30.19	33.63	33.91	34.20	34.48	33.31	33.64	34.35	33.97	34.28	30.27
	III	33.51	-82.04	35.00	34.71	34.44	33.59	34.17	34.00	33.83	33.82	33.68	33.53	27.93	32.51	32.89	33.28	33.64	32.08	32.53	33.48	32.97	33.38	28.04
	IV	35.76	-5.23	36.29	36.19	36.09	35.79	36.00	35.94	35.88	35.87	35.82	35.77	33.78	35.41	35.54	35.68	35.81	35.26	35.41	35.75	35.57	35.71	33.82
	Average	33.48	-83.30	34.98	34.69	34.41	33.55	34.14	33.97	33.80	33.79	33.65	33.49	27.84	32.47	32.85	33.24	33.61	32.03	32.48	33.44	32.93	33.34	27.95
3	I	26.42	-194.33	-10.38	31.42	30.54	26.63	24.81	25.28	25.71	27.31	26.91	26.46	10.13	23.52	24.61	25.73	26.80	22.28	23.58	26.32	24.86	26.03	13.67
	II	32.28	-53.43	17.99	34.22	33.88	32.36	31.65	31.84	32.01	32.62	32.47	32.29	25.95	31.16	31.58	32.01	32.43	30.67	31.18	32.24	31.67	32.13	27.33
	III	31.05	-82.98	12.04	33.63	33.18	31.16	30.22	30.46	30.69	31.51	31.30	31.07	22.64	29.56	30.12	30.70	31.25	28.91	29.58	31.00	30.24	30.85	24.46
	IV	34.24	-6.20	27.50	35.16	35.00	34.28	33.95	34.04	34.12	34.41	34.33	34.25	31.26	33.71	33.91	34.12	34.31	33.49	33.72	34.23	33.96	34.17	31.91
	Average	31.00	-84.24	11.79	33.61	33.15	31.11	30.16	30.41	30.63	31.46	31.25	31.02	22.50	29.49	30.06	30.64	31.20	28.84	29.52	30.95	30.18	30.80	24.34
4	I	23.13	-194.72	-11.19	-2.22	29.38	23.41	18.45	19.80	21.05	24.31	23.78	23.18	0.88	19.24	20.70	22.21	23.63	17.55	19.31	23.00	21.03	22.60	8.57
	II	30.39	-54.19	17.07	20.55	32.82	30.50	28.57	29.10	29.58	30.85	30.65	30.41	21.75	28.88	29.45	30.03	30.59	28.23	28.91	30.34	29.58	30.19	24.74
	III	28.87	-83.66	11.14	15.77	32.10	29.01	26.45	27.15	27.79	29.48	29.21	28.89	17.37	26.86	27.61	28.39	29.13	25.99	26.89	28.80	27.79	28.60	21.35
	IV	32.82	-7.09	26.54	28.18	33.97	32.88	31.97	32.22	32.44	33.04	32.94	32.83	28.75	32.11	32.38	32.66	32.92	31.80	32.12	32.80	32.44	32.73	30.16
	Average	28.80	-84.92	10.89	15.57	32.07	28.95	26.36	27.07	27.72	29.42	29.15	28.83	17.19	26.77	27.54	28.32	29.07	25.89	26.81	28.74	27.71	28.53	21.20
5	I	19.08	-192.95	-10.81	-2.87	3.47	19.49	8.76	11.77	14.53	20.78	20.03	19.16	-14.42	13.42	15.57	17.76	19.81	10.93	13.52	18.90	16.05	18.33	2.74
	II	28.21	-54.12	16.60	19.68	22.14	28.37	24.20	25.37	26.44	28.87	28.58	28.24	15.20	26.01	26.84	27.70	28.49	25.04	26.05	28.14	27.03	27.92	21.86
	III	26.30	-83.24	10.85	14.95	18.23	26.50	20.96	22.52	23.94	27.17	26.78	26.33	8.99	23.37	24.48	25.61	26.67	22.08	23.42	26.20	24.73	25.91	17.85
	IV	31.27	-7.59	25.79	27.24	28.41	31.34	29.37	29.93	30.43	31.58	31.44	31.28	25.13	30.23	30.62	31.02	31.40	29.77	30.25	31.23	30.71	31.13	28.27
	Average	26.22	-84.48	10.61	14.75	18.06	26.43	20.82	22.40	23.84	27.10	26.71	26.25	8.73	23.26	24.38	25.52	26.59	21.96	23.31	26.12	24.63	25.82	17.68
6	I	14.80	-195.17	-14.03	-6.30	-0.20	5.37	4.89	7.79	10.44	16.14	11.59	15.62	-22.09	9.13	11.29	13.72	16.07	5.18	8.26	14.72	10.11	13.59	-2.23
	II	25.32	-56.20	14.13	17.13	19.50	21.66	21.47	22.60	23.63	25.84	24.08	25.64	11.00	23.12	23.96	24.90	25.82	21.59	22.78	25.29	23.50	24.85	18.71
	III	23.11	-85.35	8.23	12.21	15.37	18.24	18.00	19.49	20.86	23.81	21.46	23.54	4.06	20.19	21.30	22.56	23.77	18.15	19.74	23.08	20.69	22.49	14.32
	IV	28.85	-9.63	23.57	24.98	26.10	27.12	27.03	27.56	28.05	29.09	28.26	29.00	22.09	27.81	28.21	28.65	29.08	27.09	27.65	28.83	27.99	28.63	25.73
	Average	23.02	-86.59	7.98	12.01	15.19	18.10	17.85	19.36	20.75	23.72	21.35	23.45	3.77	20.06	21.19	22.46	23.69	18.00	19.61	22.98	20.57	22.39	14.13
7	I	24.82	-197.46	24.76	24.91	24.97	24.99	2.78	27.08	26.45	25.53	25.21	24.85	11.92	22.50	23.37	24.27	25.12	21.51	22.54	24.74	23.56	24.50	12.86
	II	29.82	-56.48	29.80	29.86	29.88	29.89	21.27	30.70	30.46	30.10	29.98	29.83	24.81	28.92	29.26	29.61	29.94	28.54	28.94	29.79	29.34	29.70	25.18
	III	28.77	-86.04	28.74	28.82	28.85	28.86	17.39	29.94	29.62	29.14	28.98	28.79	22.11	27.58	28.02	28.49	28.93	27.06	27.60	28.73	28.13	28.61	22.60
	IV	31.50	-9.23	31.49	31.52	31.53	31.53	27.46	31.91	31.80	31.63	31.57	31.51	29.14	31.08	31.23	31.40	31.56	30.89	31.08	31.49	31.27	31.44	29.31
	Average	28.73	-87.30	28.70	28.78	28.81	28.82	17.23	29.91	29.58	29.10	28.94	28.75	22.00	27.52	27.97	28.44	28.89	27.00	27.54	28.69	28.08	28.56	22.49
8	I	23.35	-196.29	15.92	17.92	19.49	23.59	4.12	10.49	27.11	24.34	23.90	23.39	5.27	20.14	21.34	22.59	23.77	18.76	20.20	23.24	21.62	22.92	9.87
	II	29.87	-55.42	26.98	27.76	28.37	29.96	22.40	24.87	31.32	30.25	30.08	29.88	22.85	28.62	29.09	29.57	30.03	28.08	28.64	29.82	29.19	29.70	24.63
	III	28.50	-84.96	24.66	25.69	26.51	28.62	18.56	21.85	30.44	29.01	28.78	28.52	19.16	26.84	27.46	28.11	28.72	26.13	26.87	28.44	27.60	28.27	21.54
	IV	32.05	-8.20	30.69	31.05	31.34	32.09	28.52	29.69	32.74	32.23	32.15	32.06	28.74	31.46	31.68	31.91	32.13	31.21	31.47	32.03	31.73	31.97	29.58
	Average	28.44	-86.22	24.56	25.61	26.43	28.57	18.40	21.73	30.40	28.96	28.73	28.46	19.01	26.77	27.39	28.05	28.66	26.05	26.80	28.38	27.54	28.22	21.40
9	I	19.44	-173.36	-9.23	-1.67	4.49	19.61	9.73	12.66	15.28	10.83	19.63	19.48	-30.16	10.16	13.93	17.01	19.65	9.85	12.88	19.01	17.03	18.96	2.51
	II	28.96	-45.90	17.83	20.76	23.15	29.03	25.19	26.32	27.34	25.62	29.03	28.97	9.70	25.36	26.82	28.02	29.04	25.23	26.41	28.79	28.02	28.77	22.38
	III	26.96	-72.63	12.15	16.06	19.24	27.05	21.95	23.46	24.81	22.52	27.06	26.98	1.34	22.17	24.12	25.71	27.07	22.01	23.58	26.74	25.72	26.72	18.22
	IV	32.15	-3.18	26.90	28.28	29.41	32.18	30.37	30.91	31.39	30.57	32.18	32.16	23.06	30.45	31.14	31.70	32.19	30.39	30.95	32.07	31.71	32.06	29.05
	Average	26.88	-73.77	11.91	15.86	19.07	26.97	21.81	23.34	24.71	22.39	26.98	26.90	0.98	22.04	24.00	25.61	26.99	21.87	23.46	26.65	25.62	26.63	18.04

Table B.1. Nodal Hydraulic Pressure Under Average Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	15.41	-191.65	-12.92	-5.29	0.79	11.93	5.80	8.63	11.21	16.40	5.23	14.84	-26.85	9.74	11.91	14.52	17.04	3.92	7.73	15.43	8.53	13.73	-2.00
	II	26.17	-54.23	15.17	18.13	20.49	24.82	22.44	23.54	24.54	26.55	22.22	25.95	9.76	23.97	24.81	25.82	26.80	21.71	23.19	26.18	23.50	25.52	19.41
	III	23.91	-83.05	9.28	13.22	16.36	22.12	18.95	20.41	21.74	24.42	18.66	23.62	2.08	20.98	22.10	23.45	24.75	17.98	19.95	23.92	20.36	23.05	14.92
	IV	29.78	-8.16	24.59	25.98	27.10	29.14	28.02	28.53	29.01	29.96	27.91	29.67	22.03	28.74	29.13	29.61	30.08	27.67	28.37	29.78	28.52	29.47	26.59
	Average	23.82	-84.27	9.03	13.01	16.19	22.00	18.80	20.28	21.63	24.33	18.51	23.52	1.76	20.86	21.99	23.35	24.67	17.82	19.81	23.83	20.23	22.94	14.73
11	I	28.57	4.78	24.08	25.15	26.06	28.40	26.88	27.35	27.80	27.82	28.17	28.54	-65.42	30.54	29.88	29.10	28.26	31.21	30.51	28.65	29.71	28.88	22.95
	II	31.89	22.66	30.15	30.56	30.92	31.83	31.23	31.42	31.59	31.60	31.74	31.88	-4.60	32.66	32.40	32.10	31.77	32.92	32.65	31.92	32.34	32.01	29.71
	III	31.20	18.91	28.87	29.43	29.90	31.11	30.32	30.57	30.80	30.81	30.99	31.18	-17.36	32.21	31.87	31.47	31.04	32.56	32.20	31.24	31.79	31.35	28.29
	IV	33.01	28.65	32.18	32.38	32.55	32.97	32.69	32.78	32.86	32.87	32.93	33.00	15.78	33.37	33.24	33.10	32.95	33.49	33.36	33.02	33.21	33.06	31.98
	Average	31.17	18.75	28.82	29.38	29.86	31.08	30.28	30.53	30.76	30.78	30.96	31.15	-17.90	32.20	31.85	31.44	31.01	32.55	32.18	31.21	31.76	31.33	28.23
12	I	23.58	-26.44	14.22	16.46	18.36	23.32	20.06	21.05	21.98	21.58	22.93	23.53	-65.26	5.30	29.14	24.74	23.07	20.36	21.27	23.17	24.86	23.97	15.06
	II	29.95	10.53	26.32	27.19	27.93	29.85	28.59	28.97	29.33	29.18	29.70	29.94	-4.54	22.86	32.11	30.40	29.76	28.70	29.06	29.80	30.45	30.11	26.65
	III	28.62	2.78	23.78	24.94	25.92	28.48	26.80	27.31	27.79	27.58	28.28	28.59	-17.27	19.18	31.49	29.22	28.36	26.95	27.43	28.41	29.28	28.82	24.22
	IV	32.09	22.92	30.38	30.79	31.13	32.04	31.45	31.63	31.80	31.72	31.97	32.08	15.81	28.74	33.11	32.30	32.00	31.50	31.67	32.02	32.33	32.16	30.53
	Average	28.56	2.45	23.68	24.85	25.84	28.42	26.73	27.24	27.73	27.52	28.22	28.54	-17.82	19.02	31.46	29.17	28.30	26.88	27.36	28.35	29.23	28.77	24.11
13	I	17.70	-70.49	1.99	5.82	9.05	17.34	11.90	13.55	15.09	14.15	16.75	17.64	-64.73	4.59	10.45	19.61	16.96	6.76	9.90	16.71	19.16	18.20	5.82
	II	26.45	-7.79	20.35	21.84	23.09	26.31	24.19	24.84	25.43	25.07	26.08	26.42	-5.56	21.36	23.63	27.19	26.16	22.20	23.42	26.06	27.01	26.64	21.84
	III	24.61	-20.94	16.50	18.48	20.14	24.43	21.62	22.47	23.27	22.78	24.12	24.58	-17.97	17.84	20.87	25.60	24.23	18.96	20.58	24.10	25.37	24.87	18.48
	IV	29.38	13.22	26.50	27.20	27.79	29.31	28.32	28.62	28.90	28.73	29.21	29.37	14.28	26.98	28.05	29.73	29.24	27.38	27.95	29.20	29.65	29.47	27.20
	Average	24.54	-21.50	16.34	18.34	20.02	24.35	21.51	22.37	23.17	22.68	24.04	24.50	-18.50	17.69	20.75	25.53	24.15	18.83	20.46	24.02	25.30	24.80	18.34
14	I	13.08	-181.23	-14.61	-7.19	-1.21	9.84	3.78	6.56	9.06	13.56	3.28	12.56	-39.39	7.40	9.58	12.40	6.27	-1.55	3.58	13.21	2.46	10.72	-4.90
	II	24.04	-51.40	13.29	16.17	18.50	22.79	20.43	21.51	22.48	24.23	20.24	23.84	3.67	21.84	22.68	23.78	21.40	18.36	20.36	24.09	19.92	23.13	17.06
	III	21.74	-78.63	7.44	11.27	14.36	20.07	16.94	18.37	19.67	21.99	16.68	21.48	-5.36	18.81	19.94	21.39	18.22	14.19	16.84	21.81	16.26	20.53	12.46
	IV	27.72	-7.89	22.64	24.00	25.10	27.12	26.01	26.52	26.98	27.81	25.92	27.62	18.10	26.68	27.08	27.59	26.47	25.04	25.98	27.74	25.77	27.28	24.42
	Average	21.65	-79.79	7.19	11.06	14.19	19.96	16.79	18.24	19.55	21.90	16.53	21.38	-5.75	18.68	19.82	21.29	18.09	14.01	16.69	21.71	16.10	20.42	12.26
15	I	26.51	-17.48	18.31	20.28	21.95	26.14	23.43	24.30	25.12	25.43	25.66	26.44	-63.38	25.50	25.95	27.42	25.87	-1.28	32.14	26.99	29.18	27.21	18.26
	II	32.32	15.24	29.13	29.90	30.54	32.17	31.12	31.46	31.77	31.89	31.98	32.29	-2.59	31.92	32.10	32.67	32.07	21.53	34.50	32.50	33.35	32.59	29.11
	III	31.10	8.38	26.86	27.88	28.74	30.91	29.51	29.96	30.38	30.54	30.66	31.06	-15.34	30.57	30.81	31.57	30.77	16.74	34.01	31.35	32.48	31.46	26.84
	IV	34.26	26.20	32.76	33.12	33.43	34.19	33.70	33.86	34.01	34.06	34.10	34.25	17.79	34.08	34.16	34.43	34.14	29.17	35.29	34.35	34.75	34.39	32.75
	Average	31.05	8.09	26.77	27.80	28.67	30.85	29.44	29.90	30.32	30.48	30.60	31.01	-15.88	30.52	30.76	31.52	30.71	16.54	33.99	31.30	32.44	31.41	26.74
16	I	21.09	-57.55	7.01	10.44	13.33	20.41	15.88	17.36	18.74	19.49	19.55	20.96	-63.17	15.38	17.64	22.55	19.93	-1.55	6.87	22.16	25.96	22.37	9.77
	II	29.60	-0.93	24.13	25.46	26.59	29.34	27.57	28.15	28.69	28.98	29.00	29.55	-3.12	27.38	28.26	30.17	29.15	20.81	24.08	30.01	31.49	30.10	25.20
	III	27.81	-12.81	20.54	22.31	23.81	27.46	25.12	25.89	26.60	26.99	27.02	27.75	-15.71	24.86	26.03	28.57	27.22	16.12	20.47	28.37	30.33	28.48	21.97
	IV	32.45	18.04	29.87	30.50	31.03	32.33	31.50	31.77	32.02	32.16	32.17	32.43	17.01	31.40	31.82	32.72	32.24	28.30	29.85	32.65	33.34	32.69	30.38
	Average	27.74	-13.31	20.39	22.18	23.69	27.39	25.02	25.79	26.51	26.91	26.94	27.67	-16.25	24.76	25.94	28.50	27.14	15.92	20.32	28.30	30.28	28.41	21.83
17	I	17.10	-94.07	-1.81	2.90	6.83	15.36	10.25	12.22	14.04	16.63	12.46	16.80	-61.70	11.41	13.63	17.67	13.74	-2.60	5.33	17.77	-0.11	19.78	2.89
	II	27.44	-15.72	20.10	21.92	23.45	26.76	24.78	25.54	26.25	27.25	25.64	27.32	-3.16	25.23	26.09	27.66	26.13	19.79	22.87	27.70	20.76	28.48	21.92
	III	25.27	-32.15	15.50	17.93	19.97	24.37	21.73	22.75	23.69	25.02	22.87	25.12	-15.44	22.33	23.48	25.56	23.53	15.10	19.19	25.61	16.38	26.65	17.93
	IV	30.90	10.53	27.44	28.30	29.02	30.58	29.65	30.01	30.34	30.82	30.05	30.85	16.46	29.86	30.27	31.01	30.29	27.29	28.75	31.03	27.75	31.39	28.30
	Average	25.18	-32.85	15.31	17.76	19.82	24.27	21.60	22.63	23.58	24.93	22.76	25.02	-15.96	22.21	23.37	25.48	23.42	14.90	19.04	25.53	16.20	26.58	17.76

*) Refer to Table 4.11

Table B.2. Nodal Hydraulic Pressure Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	27.64	-282.35	31.61	30.87	30.15	27.83	29.41	28.95	28.49	28.50	28.10	27.67	12.50	24.95	25.95	27.01	28.00	23.81	24.98	27.55	26.21	27.27	12.96
	II	33.36	-86.99	34.91	34.62	34.34	33.44	34.05	33.88	33.69	33.70	33.54	33.38	27.49	32.32	32.71	33.12	33.50	31.88	32.33	33.33	32.81	33.22	27.67
	III	32.16	-127.96	34.22	33.83	33.46	32.27	33.08	32.84	32.60	32.61	32.40	32.18	24.34	30.78	31.29	31.84	32.35	30.19	30.79	32.12	31.43	31.97	24.58
	IV	35.28	-21.52	36.01	35.88	35.75	35.32	35.61	35.53	35.44	35.44	35.37	35.29	32.51	34.79	34.98	35.17	35.35	34.58	34.80	35.27	35.02	35.22	32.60
	Average	32.11	-129.71	34.19	33.80	33.43	32.22	33.04	32.80	32.56	32.56	32.35	32.13	24.21	30.71	31.23	31.79	32.30	30.12	30.73	32.07	31.37	31.92	24.45
3	I	22.76	-283.17	-27.87	29.67	28.49	23.05	20.54	21.19	21.80	24.05	23.44	22.81	-0.04	18.76	20.25	21.83	23.29	17.04	18.80	22.63	20.64	22.22	5.10
	II	30.86	-87.93	11.20	33.54	33.09	30.97	30.00	30.25	30.49	31.36	31.13	30.88	22.01	29.30	29.88	30.50	31.07	28.64	29.32	30.81	30.04	30.65	24.00
	III	29.16	-128.87	3.01	32.73	32.12	29.31	28.01	28.35	28.66	29.83	29.51	29.19	17.38	27.09	27.86	28.68	29.44	26.21	27.12	29.09	28.06	28.88	20.04
	IV	33.57	-22.48	24.30	34.84	34.62	33.63	33.17	33.29	33.40	33.81	33.70	33.58	29.40	32.84	33.11	33.40	33.67	32.53	32.85	33.55	33.18	33.47	30.34
	Average	29.09	-130.61	2.66	32.70	32.08	29.24	27.93	28.27	28.59	29.76	29.45	29.12	17.19	27.00	27.78	28.60	29.37	26.11	27.02	29.02	27.98	28.81	19.87
4	I	18.57	-283.33	-28.62	-16.75	27.29	18.96	12.07	13.93	15.70	20.29	19.48	18.64	-12.60	13.18	15.20	17.33	19.28	10.86	13.25	18.39	15.72	17.84	-1.61
	II	28.62	-88.60	10.30	14.91	32.00	28.77	26.10	26.82	27.51	29.29	28.98	28.65	16.52	26.53	27.31	28.14	28.90	25.63	26.55	28.55	27.51	28.34	20.79
	III	26.51	-129.44	2.14	8.27	31.01	26.72	23.16	24.12	25.03	27.40	26.99	26.55	10.41	23.73	24.77	25.87	26.88	22.53	23.76	26.42	25.04	26.14	16.09
	IV	31.99	-23.33	23.34	25.52	33.59	32.06	30.80	31.14	31.46	32.30	32.16	32.00	26.28	31.00	31.37	31.76	32.12	30.58	31.01	31.96	31.47	31.86	28.29
	Average	26.42	-131.18	1.79	7.99	30.97	26.63	23.03	24.00	24.93	27.32	26.90	26.46	10.15	23.61	24.66	25.78	26.80	22.40	23.64	26.33	24.94	26.05	15.89
5	I	13.27	-280.57	-27.82	-17.29	-8.72	13.83	-1.14	3.01	6.94	15.73	14.58	13.37	-33.78	5.40	8.36	11.46	14.29	1.96	5.49	13.01	9.13	12.21	-9.42
	II	25.95	-88.14	10.00	14.09	17.41	26.17	20.35	21.97	23.49	26.91	26.46	25.99	7.68	22.89	24.05	25.25	26.35	21.56	22.93	25.85	24.34	25.54	17.14
	III	23.29	-128.49	2.07	7.51	11.93	23.58	15.85	17.99	20.02	24.56	23.97	23.34	-1.01	19.23	20.76	22.36	23.82	17.45	19.27	23.16	21.15	22.75	11.57
	IV	30.20	-23.64	22.67	24.60	26.17	30.30	27.56	28.32	29.04	30.65	30.44	30.22	21.58	28.76	29.30	29.87	30.39	28.13	28.78	30.15	29.44	30.01	26.04
	Average	23.18	-130.21	1.73	7.23	11.70	23.47	15.66	17.82	19.87	24.46	23.86	23.23	-1.38	19.07	20.62	22.24	23.71	17.28	19.12	23.04	21.02	22.63	11.33
6	I	8.08	-282.88	-31.53	-21.28	-13.03	-5.06	-5.75	-1.75	2.02	10.03	3.62	9.22	-43.72	0.20	3.18	6.61	9.89	-5.25	-1.06	7.98	1.68	6.39	-15.56
	II	22.71	-90.26	7.33	11.31	14.51	17.61	17.34	18.89	20.36	23.47	20.98	23.16	2.60	19.65	20.81	22.14	23.42	17.54	19.16	22.67	20.23	22.06	13.53
	III	19.64	-130.65	-0.82	4.48	8.74	12.85	12.50	14.56	16.51	20.65	17.34	20.23	-7.11	15.57	17.12	18.88	20.58	12.76	14.92	19.59	16.34	18.77	7.43
	IV	27.62	-25.70	20.36	22.24	23.75	25.21	25.08	25.81	26.51	27.97	26.80	27.83	18.13	26.17	26.72	27.35	27.95	25.17	25.94	27.60	26.44	27.31	23.28
	Average	19.51	-132.37	-1.17	4.19	8.49	12.65	12.29	14.38	16.35	20.53	17.19	20.11	-7.53	15.40	16.96	18.75	20.46	12.56	14.74	19.46	16.17	18.63	7.17
7	I	21.64	-286.37	21.56	21.76	21.85	21.88	-9.12	24.80	23.91	22.68	22.19	21.68	3.55	18.42	19.62	20.89	22.07	17.06	18.46	21.53	19.93	21.20	5.05
	II	28.59	-91.00	28.56	28.64	28.67	28.68	16.65	29.82	29.47	28.99	28.80	28.61	21.57	27.34	27.81	28.30	28.76	26.81	27.35	28.55	27.93	28.42	22.15
	III	27.13	-131.97	27.09	27.19	27.24	27.25	11.24	28.76	28.30	27.67	27.42	27.15	17.79	25.47	26.09	26.74	27.35	24.76	25.49	27.07	26.25	26.90	18.56
	IV	30.92	-25.52	30.90	30.94	30.96	30.96	25.28	31.50	31.33	31.11	31.02	30.93	27.60	30.33	30.55	30.78	31.00	30.08	30.34	30.90	30.61	30.84	27.88
	Average	27.07	-133.72	27.03	27.13	27.18	27.19	11.01	28.72	28.25	27.61	27.36	27.09	17.63	25.39	26.02	26.68	27.30	24.68	25.41	27.01	26.18	26.84	18.41
8	I	19.17	-285.16	8.92	11.58	13.71	19.50	-7.66	1.15	24.41	20.61	19.94	19.23	-6.22	14.71	16.37	18.14	19.77	12.80	14.76	19.02	16.80	18.57	0.46
	II	28.24	-89.92	24.26	25.29	26.12	28.37	17.83	21.24	30.28	28.80	28.54	28.27	18.39	26.51	27.16	27.84	28.47	25.77	26.53	28.18	27.32	28.01	20.98
	III	26.34	-130.87	21.04	22.42	23.52	26.51	12.48	17.03	29.05	27.08	26.74	26.37	13.23	24.03	24.89	25.81	26.65	23.05	24.06	26.26	25.12	26.03	16.67
	IV	31.28	-24.48	29.40	29.89	30.28	31.34	26.37	27.98	32.24	31.55	31.42	31.29	26.63	30.46	30.77	31.09	31.39	30.11	30.47	31.26	30.85	31.17	27.85
	Average	26.26	-132.61	20.91	22.30	23.41	26.43	12.26	16.85	29.00	27.01	26.66	26.29	13.01	23.93	24.80	25.72	26.57	22.93	23.96	26.18	25.02	25.95	16.49
9	I	13.29	-254.16	-26.12	-16.05	-7.70	13.51	-0.20	3.81	7.53	0.61	13.51	13.34	-56.64	0.29	5.52	9.93	13.54	-0.07	4.07	12.66	10.06	12.64	-10.30
	II	26.57	-77.27	11.27	15.18	18.42	26.66	21.33	22.89	24.33	21.65	26.66	26.59	-0.58	21.52	23.56	25.27	26.67	21.38	22.99	26.33	25.32	26.32	17.41
	III	23.78	-114.37	3.43	8.63	12.94	23.90	16.82	18.89	20.81	17.23	23.90	23.81	-12.34	17.07	19.77	22.05	23.92	16.88	19.02	23.46	22.12	23.45	11.60
	IV	31.02	-17.98	23.80	25.65	27.18	31.06	28.55	29.28	29.97	28.70	31.06	31.03	18.21	28.64	29.60	30.41	31.07	28.57	29.33	30.91	30.43	30.90	26.70
	Average	23.67	-115.95	3.10	8.35	12.71	23.78	16.63	18.72	20.66	17.05	23.78	23.69	-12.84	16.88	19.61	21.92	23.80	16.69	18.85	23.34	21.98	23.33	11.35

Table B.2. Nodal Hydraulic Pressure Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	8.54	-278.39	-30.39	-20.26	-12.05	3.69	-4.87	-0.97	2.70	9.96	-5.63	7.75	-50.84	0.65	3.65	7.32	10.85	-7.39	-2.21	8.57	-0.85	6.20	-15.64
	II	23.50	-87.91	8.39	12.32	15.51	21.62	18.30	19.81	21.23	24.05	18.00	23.20	0.45	20.44	21.60	23.03	24.40	17.32	19.33	23.51	19.86	22.59	14.12
	III	20.36	-127.85	0.26	5.49	9.73	17.86	13.44	15.45	17.35	21.10	13.04	19.96	-10.31	16.29	17.84	19.74	21.56	12.14	14.81	20.38	15.52	19.15	7.88
	IV	28.52	-24.06	21.38	23.24	24.74	27.63	26.06	26.77	27.45	28.78	25.92	28.37	17.64	27.07	27.62	28.30	28.94	25.60	26.55	28.52	26.80	28.09	24.09
	Average	20.23	-129.55	-0.09	5.20	9.48	17.70	13.23	15.27	17.18	20.97	12.83	19.82	-10.77	16.11	17.68	19.60	21.44	11.92	14.62	20.25	15.33	19.01	7.61
11	I	26.35	-6.79	20.13	21.56	22.80	26.11	23.97	24.63	25.27	25.25	25.78	26.31	-106.19	29.10	28.18	27.07	25.91	30.03	29.08	26.46	27.92	26.78	18.44
	II	31.03	18.16	28.61	29.17	29.65	30.94	30.11	30.36	30.61	30.60	30.81	31.01	-20.43	32.10	31.74	31.31	30.86	32.46	32.09	31.07	31.64	31.20	27.96
	III	30.05	12.93	26.83	27.57	28.22	29.92	28.82	29.16	29.49	29.48	29.75	30.03	-38.42	31.47	30.99	30.42	29.82	31.95	31.46	30.10	30.86	30.27	25.96
	IV	32.60	26.53	31.46	31.72	31.95	32.55	32.16	32.28	32.40	32.40	32.49	32.59	8.31	33.10	32.93	32.73	32.52	33.27	33.10	32.62	32.89	32.68	31.15
	Average	30.01	12.71	26.76	27.51	28.16	29.88	28.77	29.11	29.44	29.43	29.71	29.99	-39.18	31.44	30.96	30.38	29.78	31.93	31.43	30.06	30.83	30.23	25.88
12	I	19.40	-50.15	6.48	9.47	12.05	19.05	14.49	15.86	17.18	16.47	18.49	19.34	-105.94	-6.11	27.17	20.99	18.69	14.96	16.21	18.84	21.18	19.96	7.46
	II	28.33	1.33	23.31	24.47	25.48	28.19	26.42	26.96	27.47	27.19	27.98	28.31	-20.34	18.42	31.35	28.95	28.05	26.61	27.09	28.11	29.02	28.55	23.69
	III	26.46	-9.47	19.78	21.33	22.66	26.28	23.92	24.63	25.31	24.94	25.99	26.43	-38.29	13.28	30.47	27.28	26.09	24.17	24.81	26.17	27.38	26.75	20.29
	IV	31.33	18.58	28.96	29.50	29.98	31.26	30.42	30.68	30.92	30.79	31.16	31.31	8.36	26.65	32.75	31.62	31.19	30.51	30.74	31.22	31.65	31.43	29.14
	Average	26.38	-9.93	19.63	21.19	22.54	26.20	23.81	24.53	25.22	24.85	25.91	26.35	-39.05	13.06	30.44	27.21	26.01	24.06	24.71	26.09	27.31	26.67	20.14
13	I	11.98	-110.62	-9.71	-4.60	-0.22	11.48	3.87	6.15	8.35	6.75	10.65	11.89	-104.36	-6.35	1.81	14.60	10.93	-3.20	1.08	10.59	13.99	12.68	-4.65
	II	24.23	-23.37	15.80	17.79	19.49	24.03	21.08	21.96	22.82	22.20	23.71	24.19	-20.95	17.11	20.28	25.24	23.82	18.33	19.99	23.69	25.01	24.50	17.77
	III	21.66	-41.67	10.45	13.09	15.36	21.40	17.47	18.65	19.78	18.96	20.97	21.61	-38.44	12.19	16.41	23.01	21.11	13.82	16.03	20.94	22.70	22.02	13.07
	IV	28.33	5.87	24.36	25.29	26.10	28.24	26.85	27.26	27.67	27.37	28.09	28.32	7.01	24.97	26.47	28.81	28.14	25.55	26.33	28.08	28.70	28.46	25.29
	Average	21.55	-42.45	10.23	12.89	15.18	21.29	17.32	18.51	19.66	18.82	20.86	21.50	-39.19	11.98	16.24	22.92	21.00	13.63	15.86	20.83	22.60	21.92	12.87
14	I	6.06	-263.30	-31.99	-22.14	-14.05	1.56	-6.91	-3.08	0.48	6.73	-7.58	5.35	-67.82	-1.84	1.18	5.15	-3.63	-14.26	-7.26	6.25	-8.45	2.76	-18.95
	II	21.32	-83.27	6.54	10.37	13.51	19.57	16.28	17.77	19.15	21.58	16.02	21.04	-7.37	18.25	19.42	20.96	17.55	13.43	16.14	21.39	15.68	20.03	11.61
	III	18.12	-121.02	-1.54	3.55	7.73	15.79	11.42	13.39	15.23	18.46	11.07	17.75	-20.05	14.04	15.60	17.65	13.11	7.62	11.24	18.22	10.62	16.41	5.20
	IV	26.43	-22.93	19.46	21.26	22.75	25.61	24.05	24.75	25.41	26.55	23.93	26.30	12.89	24.98	25.54	26.26	24.65	22.71	23.99	26.47	23.77	25.82	21.85
	Average	17.98	-122.63	-1.88	3.26	7.49	15.63	11.21	13.21	15.07	18.33	10.86	17.61	-20.59	13.86	15.44	17.51	12.92	7.38	11.03	18.08	10.41	16.26	4.93
15	I	22.73	-38.40	11.42	14.04	16.30	22.21	18.43	19.63	20.79	21.15	21.54	22.63	-104.11	21.34	21.96	23.96	21.81	-15.76	30.58	23.40	26.39	23.71	11.17
	II	30.85	7.11	26.45	27.47	28.35	30.65	29.18	29.64	30.09	30.23	30.39	30.81	-18.40	30.31	30.55	31.33	30.49	15.90	33.90	31.11	32.27	31.23	26.36
	III	29.15	-2.43	23.30	24.66	25.83	28.88	26.92	27.54	28.14	28.33	28.53	29.10	-36.38	28.42	28.75	29.78	28.67	9.26	33.20	29.49	31.03	29.65	23.17
	IV	33.57	22.37	31.50	31.98	32.39	33.47	32.78	33.00	33.21	33.28	33.35	33.55	10.33	33.31	33.43	33.79	33.40	26.52	35.01	33.69	34.24	33.75	31.45
	Average	29.08	-2.84	23.17	24.54	25.72	28.80	26.83	27.45	28.06	28.25	28.45	29.02	-37.14	28.35	28.67	29.72	28.59	8.98	33.17	29.42	30.98	29.59	23.04
16	I	15.52	-93.76	-3.90	0.67	4.59	14.58	8.24	10.29	12.25	13.21	13.38	15.35	-103.38	7.56	10.70	17.53	13.88	-15.78	-4.35	17.03	22.21	17.33	-0.31
	II	27.44	-14.99	19.89	21.67	23.19	27.07	24.61	25.40	26.17	26.54	26.61	27.37	-18.73	24.35	25.57	28.21	26.80	15.28	19.72	28.02	30.03	28.14	21.29
	III	24.94	-31.51	14.90	17.27	19.29	24.45	21.18	22.23	23.25	23.74	23.83	24.85	-36.48	20.83	22.45	25.97	24.09	8.77	14.67	25.72	28.39	25.87	16.76
	IV	31.43	11.41	27.87	28.71	29.43	31.26	30.10	30.47	30.83	31.01	31.04	31.40	9.64	29.97	30.55	31.80	31.13	25.69	27.79	31.71	32.66	31.76	28.53
	Average	24.83	-32.21	14.69	17.08	19.13	24.34	21.03	22.10	23.13	23.63	23.72	24.74	-37.24	20.68	22.32	25.88	23.98	8.49	14.46	25.62	28.32	25.78	16.57
17	I	10.49	-143.62	-15.52	-9.25	-3.93	8.08	0.95	3.66	6.25	9.79	4.07	10.08	-100.70	2.56	5.65	11.28	5.74	-16.84	-6.02	11.43	-12.85	14.20	-9.30
	II	24.87	-34.97	14.77	17.21	19.27	23.94	21.17	22.22	23.22	24.60	22.38	24.71	-18.30	21.79	22.99	25.18	23.03	14.26	18.46	25.24	15.81	26.31	17.19
	III	21.86	-57.75	8.42	11.66	14.41	20.61	16.93	18.33	19.66	21.49	18.54	21.64	-35.58	17.76	19.35	22.26	19.40	7.74	13.32	22.34	9.80	23.77	11.63
	IV	29.69	1.45	24.93	26.07	27.05	29.25	27.94	28.44	28.91	29.56	28.52	29.62	9.32	28.24	28.80	29.84	28.82	24.68	26.67	29.86	25.41	30.37	26.07
	Average	21.73	-58.72	8.15	11.42	14.20	20.47	16.75	18.16	19.51	21.36	18.38	21.51	-36.32	17.59	19.20	22.14	19.25	7.46	13.11	22.22	9.54	23.66	11.40

*) Refer to Table 4.11

Table B.3. Nodal Hydraulic Pressure Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	32.53	-115.61	34.47	34.09	33.74	32.63	33.38	33.17	32.95	32.93	32.76	32.55	25.33	31.24	31.74	32.23	32.70	30.66	31.27	32.49	31.82	32.37	25.52
	II	35.27	-22.26	36.02	35.87	35.73	35.30	35.59	35.51	35.43	35.42	35.35	35.27	32.47	34.76	34.96	35.15	35.33	34.54	34.78	35.25	34.99	35.20	32.54
	III	34.69	-41.83	35.69	35.50	35.31	34.74	35.13	35.02	34.91	34.90	34.81	34.70	30.97	34.02	34.28	34.54	34.78	33.73	34.04	34.67	34.32	34.61	31.07
	IV	36.18	9.04	36.54	36.47	36.40	36.20	36.34	36.30	36.26	36.25	36.22	36.18	34.86	35.94	36.04	36.13	36.21	35.84	35.95	36.17	36.05	36.15	34.90
	Average	34.67	-42.67	35.68	35.48	35.30	34.72	35.11	35.00	34.89	34.88	34.79	34.68	30.91	33.99	34.26	34.51	34.76	33.69	34.01	34.65	34.30	34.58	31.01
3	I	29.61	-116.55	4.70	32.98	32.39	29.76	28.53	28.84	29.13	30.20	29.95	29.64	18.71	27.66	28.42	29.16	29.86	26.80	27.72	29.55	28.54	29.37	21.14
	II	33.52	-23.23	23.85	34.83	34.60	33.58	33.10	33.22	33.33	33.75	33.65	33.53	29.29	32.76	33.06	33.34	33.62	32.43	32.78	33.50	33.10	33.42	30.23
	III	32.70	-42.80	19.83	34.44	34.14	32.78	32.14	32.30	32.45	33.01	32.87	32.71	27.07	31.69	32.08	32.47	32.83	31.25	31.72	32.67	32.15	32.57	28.32
	IV	34.83	8.05	30.26	35.45	35.34	34.86	34.63	34.69	34.74	34.94	34.89	34.83	32.83	34.47	34.61	34.75	34.88	34.31	34.48	34.82	34.63	34.78	33.28
	Average	32.67	-43.63	19.66	34.43	34.12	32.75	32.10	32.26	32.41	32.98	32.84	32.68	26.98	31.65	32.04	32.43	32.80	31.20	31.68	32.64	32.11	32.54	28.24
4	I	27.07	-117.16	3.83	9.99	31.28	27.26	23.94	24.82	25.66	27.86	27.52	27.10	12.16	24.45	25.46	26.46	27.40	23.28	24.52	26.99	25.63	26.74	17.38
	II	31.92	-24.08	22.90	25.29	33.56	32.00	30.71	31.05	31.37	32.23	32.10	31.93	26.13	30.90	31.30	31.69	32.05	30.45	30.93	31.89	31.36	31.79	28.16
	III	30.90	-43.60	18.90	22.08	33.08	31.00	29.29	29.74	30.17	31.31	31.14	30.92	23.20	29.55	30.07	30.59	31.08	28.95	29.59	30.86	30.16	30.73	25.90
	IV	33.55	7.12	29.29	30.42	34.32	33.58	32.97	33.14	33.29	33.69	33.63	33.55	30.81	33.07	33.25	33.44	33.61	32.85	33.08	33.53	33.28	33.49	31.77
	Average	30.86	-44.43	18.73	21.95	33.06	30.96	29.23	29.69	30.12	31.27	31.10	30.88	23.08	29.49	30.02	30.55	31.04	28.88	29.53	30.82	30.11	30.69	25.80
5	I	24.01	-116.38	3.77	9.22	13.47	24.29	17.12	19.08	20.93	25.14	24.66	24.06	1.54	20.19	21.68	23.14	24.49	18.46	20.29	23.90	21.93	23.54	13.12
	II	30.12	-24.39	22.26	24.38	26.03	30.23	27.45	28.21	28.92	30.56	30.37	30.14	21.40	28.64	29.22	29.78	30.31	27.97	28.68	30.08	29.31	29.94	25.89
	III	28.84	-43.68	18.39	21.20	23.40	28.99	25.28	26.29	27.25	29.42	29.18	28.87	17.23	26.87	27.64	28.39	29.09	25.97	26.92	28.78	27.76	28.60	23.21
	IV	32.17	6.45	28.46	29.46	30.24	32.22	30.91	31.27	31.60	32.38	32.29	32.18	28.05	31.47	31.74	32.01	32.26	31.15	31.49	32.15	31.79	32.08	30.17
	Average	28.79	-44.50	18.22	21.07	23.29	28.93	25.19	26.21	27.18	29.38	29.13	28.81	17.06	26.79	27.57	28.33	29.04	25.89	26.85	28.73	27.70	28.54	23.10
6	I	20.41	-118.56	0.91	6.21	10.29	13.82	13.80	15.68	17.45	21.29	18.17	20.99	-4.36	16.58	18.08	19.70	21.27	13.85	16.03	20.36	17.16	19.64	9.04
	II	27.50	-26.46	19.93	21.99	23.57	24.94	24.93	25.66	26.35	27.84	26.63	27.72	17.88	26.01	26.59	27.22	27.83	24.95	25.80	27.48	26.24	27.20	23.08
	III	26.01	-45.77	15.94	18.68	20.79	22.61	22.60	23.57	24.49	26.47	24.86	26.31	13.22	24.03	24.81	25.64	26.46	22.62	23.75	25.99	24.33	25.62	20.14
	IV	29.88	4.41	26.30	27.27	28.02	28.67	28.67	29.01	29.33	30.04	29.47	29.98	25.34	29.17	29.45	29.75	30.03	28.67	29.07	29.87	29.28	29.74	27.79
	Average	25.95	-46.60	15.77	18.54	20.67	22.51	22.50	23.48	24.41	26.41	24.78	26.25	13.02	23.95	24.73	25.58	26.40	22.52	23.66	25.93	24.25	25.55	20.01
7	I	27.58	-119.62	27.54	27.65	27.69	27.70	12.91	29.09	28.68	28.06	27.85	27.60	18.97	26.03	26.63	27.22	27.78	25.35	26.07	27.53	26.73	27.39	19.66
	II	30.90	-26.26	30.88	30.92	30.94	30.94	25.20	31.48	31.32	31.08	31.00	30.90	27.55	30.29	30.53	30.76	30.97	30.03	30.31	30.88	30.56	30.82	27.82
	III	30.20	-45.84	30.18	30.23	30.26	30.26	22.62	30.98	30.77	30.45	30.34	30.21	25.75	29.40	29.71	30.01	30.30	29.05	29.42	30.18	29.76	30.10	26.11
	IV	32.01	5.03	32.00	32.02	32.03	32.03	29.32	32.28	32.21	32.09	32.06	32.01	30.43	31.72	31.83	31.94	32.04	31.60	31.73	32.00	31.85	31.97	30.55
	Average	30.17	-46.67	30.15	30.21	30.23	30.23	22.51	30.96	30.75	30.42	30.31	30.18	25.68	29.36	29.68	29.98	30.27	29.01	29.38	30.15	29.73	30.07	26.03
8	I	26.92	-118.52	21.89	23.26	24.32	27.08	14.12	18.22	29.45	27.57	27.29	26.95	14.83	24.76	25.59	26.42	27.20	23.80	24.82	26.85	25.73	26.64	17.96
	II	31.25	-25.22	29.30	29.83	30.24	31.31	26.28	27.87	32.23	31.50	31.40	31.26	26.56	30.41	30.73	31.06	31.36	30.04	30.43	31.22	30.79	31.14	27.77
	III	30.34	-44.79	27.74	28.45	29.00	30.42	23.73	25.85	31.65	30.68	30.54	30.36	24.10	29.23	29.66	30.08	30.48	28.73	29.26	30.31	29.73	30.20	25.72
	IV	32.70	6.05	31.78	32.03	32.23	32.73	30.36	31.11	33.17	32.82	32.77	32.71	30.49	32.31	32.46	32.61	32.75	32.13	32.32	32.69	32.48	32.65	31.06
	Average	30.30	-45.62	27.68	28.39	28.95	30.39	23.62	25.76	31.63	30.64	30.50	30.32	24.00	29.18	29.61	30.04	30.45	28.68	29.21	30.27	29.68	30.16	25.63
9	I	24.58	-103.10	5.17	10.37	14.49	24.69	18.10	20.00	21.76	18.85	24.70	24.61	-8.71	18.32	20.93	22.97	24.71	18.05	20.19	24.31	22.91	24.29	13.28
	II	30.95	-18.62	23.42	25.44	27.04	31.00	28.44	29.18	29.86	28.73	31.00	30.96	18.03	28.53	29.54	30.33	31.00	28.42	29.25	30.85	30.31	30.84	26.57
	III	29.62	-36.34	19.59	22.28	24.41	29.68	26.27	27.25	28.16	26.66	29.68	29.63	12.42	26.39	27.73	28.79	29.68	26.24	27.35	29.48	28.76	29.47	23.78
	IV	33.09	9.69	29.53	30.49	31.24	33.11	31.90	32.25	32.57	32.04	33.11	33.10	26.99	31.94	32.42	32.80	33.11	31.89	32.29	33.04	32.79	33.04	31.02
	Average	29.56	-37.09	19.43	22.15	24.30	29.62	26.18	27.17	28.09	26.57	29.62	29.58	12.18	26.30	27.66	28.72	29.63	26.15	27.27	29.42	28.69	29.41	23.66

Table B.3. Nodal Hydraulic Pressure Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10.	I	21.13	-115.95	1.98	7.22	11.28	18.70	14.73	16.56	18.29	21.77	14.04	20.73	-7.27	17.30	18.80	20.55	22.24	13.28	15.97	21.15	16.34	20.06	9.50
	II	28.39	-24.83	20.95	22.99	24.57	27.45	25.91	26.62	27.29	28.64	25.64	28.24	17.36	26.90	27.49	28.17	28.82	25.34	26.39	28.40	26.53	27.98	23.87
	III	26.87	-43.94	16.98	19.68	21.78	25.62	23.56	24.51	25.40	27.20	23.21	26.66	12.20	24.89	25.67	26.57	27.44	22.81	24.20	26.88	24.39	26.32	20.86
	IV	30.83	5.71	27.32	28.28	29.02	30.38	29.65	29.99	30.30	30.94	29.53	30.75	25.62	30.12	30.40	30.72	31.03	29.39	29.88	30.83	29.95	30.63	28.69
	Average	26.81	-44.75	16.81	19.54	21.66	25.54	23.46	24.42	25.32	27.14	23.11	26.60	11.98	24.80	25.59	26.50	27.38	22.71	24.11	26.82	24.30	26.25	20.73
11.	I	30.36	14.57	27.32	28.05	28.67	30.24	29.23	29.54	29.84	29.86	30.08	30.34	-32.88	31.69	31.23	30.71	30.16	32.15	31.66	30.41	31.14	30.55	26.59
	II	32.59	26.45	31.41	31.69	31.93	32.54	32.15	32.27	32.38	32.39	32.48	32.58	8.03	33.10	32.92	32.72	32.51	33.28	33.09	32.61	32.89	32.66	31.12
	III	32.12	23.96	30.55	30.93	31.24	32.06	31.53	31.69	31.85	31.86	31.98	32.11	-0.55	32.81	32.57	32.30	32.01	33.04	32.79	32.14	32.53	32.22	30.17
	IV	33.33	30.44	32.78	32.91	33.02	33.31	33.13	33.18	33.24	33.24	33.28	33.33	21.74	33.58	33.49	33.40	33.30	33.66	33.57	33.34	33.48	33.37	32.64
	Average	32.10	23.86	30.52	30.90	31.22	32.04	31.51	31.67	31.83	31.84	31.96	32.09	-0.92	32.80	32.55	32.28	32.00	33.03	32.78	32.13	32.51	32.20	30.13
12.	I	26.97	-6.29	20.62	22.16	23.43	26.78	24.61	25.25	25.88	25.63	26.52	26.94	-32.78	14.64	30.70	27.73	26.63	24.76	25.41	26.72	27.86	27.22	21.25
	II	31.27	18.36	28.80	29.40	29.90	31.20	30.35	30.60	30.85	30.75	31.10	31.26	8.07	26.48	32.72	31.57	31.14	30.41	30.67	31.17	31.61	31.37	29.05
	III	30.37	13.19	27.09	27.88	28.54	30.27	29.15	29.48	29.81	29.68	30.14	30.35	-0.50	24.00	32.30	30.76	30.19	29.23	29.56	30.24	30.83	30.50	27.41
	IV	32.71	26.62	31.55	31.83	32.06	32.68	32.28	32.40	32.51	32.47	32.63	32.71	21.76	30.45	33.40	32.85	32.65	32.31	32.43	32.67	32.87	32.76	31.66
	Average	30.33	12.97	27.02	27.82	28.48	30.23	29.10	29.43	29.76	29.63	30.10	30.32	-0.86	23.89	32.28	30.73	30.15	29.18	29.52	30.20	30.79	30.46	27.34
13.	I	22.40	-36.08	11.78	14.40	16.57	22.14	18.53	19.60	20.64	20.05	21.75	22.36	-33.03	13.56	17.62	23.66	21.90	14.98	17.20	21.80	23.42	22.73	14.45
	II	28.27	5.57	24.15	25.17	26.01	28.17	26.77	27.19	27.59	27.36	28.02	28.26	6.75	24.84	26.42	28.76	28.08	25.39	26.25	28.04	28.67	28.40	25.19
	III	27.04	-3.17	21.55	22.91	24.03	26.91	25.04	25.60	26.13	25.83	26.71	27.02	-1.59	22.47	24.57	27.69	26.78	23.21	24.35	26.73	27.57	27.21	22.94
	IV	30.24	19.52	28.29	28.78	29.17	30.19	29.53	29.73	29.92	29.81	30.12	30.23	20.08	28.62	29.37	30.47	30.15	28.88	29.29	30.13	30.43	30.30	28.78
	Average	26.99	-3.54	21.44	22.82	23.95	26.85	24.97	25.53	26.07	25.76	26.65	26.97	-1.95	22.37	24.50	27.65	26.73	23.12	24.27	26.68	27.52	27.16	22.84
14	I	18.91	-109.76	0.19	5.28	9.28	16.65	12.72	14.51	16.19	19.21	12.08	18.55	-16.33	15.06	16.58	18.47	14.37	8.91	12.53	19.00	11.50	17.41	6.88
	II	26.30	-23.65	19.04	21.01	22.57	25.43	23.90	24.60	25.25	26.42	23.65	26.16	12.62	24.81	25.40	26.14	24.54	22.42	23.83	26.34	23.43	25.72	21.63
	III	24.75	-41.71	15.08	17.71	19.78	23.59	21.56	22.48	23.35	24.91	21.23	24.57	6.55	22.77	23.55	24.53	22.41	19.59	21.46	24.80	20.93	23.98	18.54
	IV	28.78	5.21	25.35	26.29	27.02	28.37	27.65	27.98	28.29	28.84	27.53	28.72	22.33	28.08	28.36	28.70	27.95	26.95	27.62	28.80	27.43	28.51	26.58
	Average	24.69	-42.48	14.92	17.57	19.66	23.51	21.46	22.39	23.27	24.85	21.12	24.50	6.29	22.68	23.47	24.46	22.32	19.47	21.36	24.74	20.82	23.91	18.41
15	I	29.58	0.29	24.00	25.36	26.48	29.32	27.51	28.08	28.63	28.85	28.99	29.33	-30.86	28.87	29.19	30.18	29.15	10.48	33.38	29.88	31.42	30.02	24.02
	II	33.51	22.13	31.34	31.87	32.30	33.41	32.70	32.92	33.14	33.22	33.28	33.49	10.04	33.23	33.36	33.74	33.34	26.09	34.98	33.62	34.22	33.68	31.35
	III	32.68	17.55	29.80	30.50	31.08	32.55	31.61	31.91	32.19	32.31	32.38	32.66	1.46	32.31	32.48	32.99	32.46	22.82	34.65	32.84	33.63	32.91	29.81
	IV	34.82	29.46	33.80	34.05	34.26	34.78	34.44	34.55	34.65	34.69	34.71	34.81	23.75	34.69	34.75	34.93	34.74	31.32	35.52	34.88	35.16	34.90	33.80
	Average	32.65	17.36	29.74	30.45	31.03	32.52	31.57	31.87	32.15	32.27	32.34	32.62	1.10	32.28	32.45	32.96	32.42	22.68	34.63	32.81	33.61	32.88	29.74
16	I	25.63	-26.64	16.07	18.43	20.37	25.17	22.13	23.10	24.03	24.56	24.57	25.54	-31.06	21.74	23.32	26.60	24.87	10.02	16.04	26.29	28.96	26.43	18.01
	II	31.36	11.07	27.65	28.57	29.32	31.18	30.00	30.38	30.74	30.94	30.95	31.33	9.35	29.85	30.46	31.74	31.07	25.30	27.64	31.62	32.66	31.67	28.40
	III	30.16	3.16	25.22	26.44	27.44	29.92	28.35	28.85	29.33	29.60	29.61	30.11	0.88	28.15	28.97	30.66	29.77	22.10	25.21	30.50	31.88	30.57	26.22
	IV	33.28	23.71	31.53	31.96	32.32	33.20	32.64	32.82	32.99	33.09	33.09	33.27	22.90	32.57	32.86	33.46	33.14	30.42	31.53	33.40	33.89	33.43	31.89
	Average	30.11	2.83	25.12	26.35	27.36	29.87	28.28	28.79	29.27	29.55	29.56	30.06	0.52	28.08	28.90	30.62	29.71	21.96	25.11	30.45	31.85	30.53	26.13
17	I	22.53	-51.52	9.64	12.89	15.55	21.30	17.92	19.20	20.43	22.23	19.25	22.31	-30.50	18.66	20.21	22.89	20.25	8.98	14.63	22.93	10.36	24.24	12.93
	II	29.55	0.79	24.54	25.81	26.83	29.07	27.76	28.25	28.73	29.43	28.27	29.46	8.96	28.04	28.65	29.69	28.66	24.28	26.48	29.70	24.82	30.21	25.82
	III	28.07	-10.18	21.42	23.10	24.47	27.44	25.69	26.36	26.99	27.92	26.38	27.96	0.68	26.08	26.88	28.26	26.90	21.07	24.00	28.28	21.79	28.96	23.11
	IV	31.90	18.33	29.54	30.13	30.62	31.67	31.05	31.29	31.51	31.84	31.30	31.86	22.18	31.19	31.47	31.96	31.48	29.41	30.45	31.97	29.67	32.21	30.14
	Average	28.01	-10.65	21.29	22.98	24.37	27.37	25.61	26.28	26.92	27.86	26.30	27.90	0.33	25.99	26.80	28.20	26.82	20.94	23.89	28.22	21.66	28.91	23.00

*) Refer to Table 4.11

Table B.4. Nodal Hydraulic Pressure Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																						Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	27.51	-282.47	31.49	30.75	30.03	27.71	29.29	28.83	28.36	28.38	27.97	27.55	12.38	24.83	25.83	26.89	27.87	23.69	24.86	27.42	26.09	27.15	12.84
	II	30.44	-89.92	31.98	31.70	31.42	30.52	31.13	30.95	30.77	30.78	30.62	30.45	24.56	29.40	29.79	30.20	30.58	28.95	29.41	30.41	29.89	30.30	24.74
	III	27.50	-132.63	29.55	29.17	28.80	27.60	28.41	28.18	27.94	27.95	27.74	27.52	19.68	26.11	26.63	27.17	27.68	25.52	26.13	27.45	26.76	27.31	19.92
	IV	28.65	-28.16	29.37	29.24	29.11	28.68	28.97	28.89	28.80	28.80	28.73	28.65	25.87	28.15	28.34	28.53	28.71	27.94	28.16	28.63	28.38	28.58	25.96
	Average	28.53	-133.30	30.60	30.22	29.84	28.63	29.45	29.21	28.97	28.98	28.77	28.54	20.62	27.12	27.65	28.20	28.71	26.53	27.14	28.48	27.78	28.34	20.86
3	I	22.64	-283.30	-27.99	29.55	28.37	22.93	20.42	21.07	21.67	23.93	23.32	22.69	-0.16	18.63	20.13	21.71	23.17	16.92	18.68	22.50	20.51	22.09	4.98
	II	27.94	-90.85	8.28	30.62	30.16	28.05	27.07	27.33	27.56	28.44	28.20	27.96	19.08	26.38	26.96	27.57	28.14	25.72	26.40	27.88	27.11	27.72	21.08
	III	24.50	-133.54	-1.66	28.06	27.46	24.65	23.35	23.68	24.00	25.16	24.85	24.52	12.72	22.43	23.20	24.01	24.77	21.54	22.45	24.43	23.40	24.21	15.37
	IV	26.94	-29.12	17.66	28.20	27.99	26.99	26.53	26.65	26.76	27.17	27.06	26.95	22.76	26.20	26.48	26.77	27.03	25.89	26.21	26.91	26.55	26.84	23.70
	Average	25.51	-134.20	-0.93	29.11	28.50	25.66	24.34	24.68	25.00	26.18	25.86	25.53	13.60	23.41	24.19	25.02	25.78	22.52	23.44	25.43	24.39	25.22	16.28
4	I	18.45	-283.45	-28.74	-16.87	27.16	18.84	11.95	13.81	15.58	20.17	19.36	18.52	-12.72	13.06	15.08	17.20	19.16	10.74	13.12	18.27	15.60	17.72	-1.73
	II	25.70	-91.52	7.37	11.98	29.08	25.85	23.17	23.90	24.58	26.36	26.05	25.73	13.60	23.61	24.39	25.21	25.97	22.70	23.63	25.63	24.59	25.41	17.86
	III	21.85	-134.10	-2.53	3.60	26.35	22.05	18.49	19.45	20.36	22.74	22.32	21.89	5.75	19.07	20.11	21.20	22.22	17.87	19.10	21.75	20.38	21.47	11.43
	IV	25.35	-29.97	16.70	18.88	26.95	25.42	24.16	24.50	24.82	25.67	25.52	25.36	19.64	24.36	24.73	25.12	25.48	23.94	24.38	25.32	24.83	25.22	21.65
	Average	22.84	-134.76	-1.80	4.40	27.39	23.04	19.44	20.42	21.34	23.74	23.31	22.88	6.57	20.03	21.08	22.18	23.21	18.81	20.06	22.74	21.35	22.46	12.30
5	I	13.14	-280.69	-27.95	-17.41	-8.85	13.71	-1.27	2.88	6.82	15.61	14.46	13.25	-33.90	5.27	8.24	11.34	14.17	1.83	5.37	12.88	9.00	12.09	-9.55
	II	23.03	-91.06	7.07	11.16	14.49	23.25	17.43	19.04	20.57	23.98	23.54	23.07	4.76	19.97	21.12	22.33	23.42	18.63	20.01	22.92	21.42	22.62	14.22
	III	18.62	-133.16	-2.60	2.84	7.27	18.92	11.18	13.32	15.36	19.90	19.30	18.68	-5.68	14.56	16.09	17.69	19.15	12.78	14.61	18.49	16.49	18.08	6.90
	IV	23.56	-30.28	16.03	17.96	19.53	23.67	20.92	21.68	22.40	24.01	23.80	23.58	14.94	22.12	22.66	23.23	23.75	21.49	22.14	23.51	22.80	23.37	19.40
	Average	19.59	-133.80	-1.86	3.64	8.11	19.89	12.07	14.23	16.29	20.88	20.28	19.65	-4.97	15.48	17.03	18.65	20.12	13.68	15.53	19.45	17.43	19.04	7.74
6	I	7.96	-283.00	-31.65	-21.41	-13.16	-5.19	-5.87	-1.88	1.90	9.90	3.49	9.10	-43.84	0.08	3.06	6.48	9.77	-5.38	-1.19	7.85	1.55	6.27	-15.69
	II	19.79	-93.18	4.41	8.39	11.59	14.69	14.42	15.97	17.44	20.54	18.05	20.23	-0.32	16.73	17.89	19.22	20.49	14.61	16.24	19.75	17.30	19.13	10.61
	III	14.98	-135.32	-5.48	-0.19	4.07	8.19	7.84	9.90	11.85	15.98	12.67	15.57	-11.78	10.91	12.45	14.22	15.91	8.09	10.25	14.92	11.67	14.11	2.76
	IV	20.98	-32.34	13.72	15.60	17.11	18.57	18.45	19.18	19.87	21.34	20.16	21.19	11.49	19.53	20.08	20.71	21.31	18.54	19.30	20.96	19.81	20.67	16.65
	Average	15.93	-135.96	-4.75	0.60	4.90	9.07	8.71	10.79	12.77	16.94	13.59	16.52	-11.11	11.81	13.37	15.16	16.87	8.97	11.15	15.87	12.58	15.05	3.58
7	I	21.52	-286.49	21.44	21.64	21.72	21.75	-9.24	24.68	23.78	22.56	22.07	21.56	3.43	18.30	19.50	20.77	21.95	16.93	18.34	21.41	19.81	21.08	4.93
	II	25.66	-93.93	25.63	25.71	25.74	25.76	13.72	26.89	26.55	26.07	25.88	25.68	18.64	24.42	24.88	25.37	25.83	23.89	24.43	25.62	25.00	25.49	19.22
	III	22.47	-136.64	22.42	22.53	22.57	22.59	6.58	24.10	23.64	23.00	22.75	22.49	13.12	20.81	21.42	22.08	22.69	20.10	20.82	22.41	21.58	22.24	13.90
	IV	24.28	-32.16	24.27	24.30	24.32	24.32	18.64	24.86	24.70	24.47	24.38	24.29	20.97	23.69	23.91	24.14	24.36	23.44	23.70	24.26	23.97	24.20	21.24
	Average	23.48	-137.31	23.44	23.55	23.59	23.61	7.43	25.13	24.67	24.03	23.77	23.51	14.04	21.81	22.43	23.09	23.71	21.09	21.82	23.43	22.59	23.25	14.82
8	I	19.05	-285.28	8.80	11.46	13.59	19.38	-7.78	1.02	24.29	20.49	19.81	19.11	-6.34	14.58	16.25	18.01	19.65	12.68	14.63	18.90	16.68	18.44	0.34
	II	25.32	-92.85	21.34	22.37	23.20	25.45	14.90	18.32	27.35	25.88	25.62	25.34	15.46	23.58	24.23	24.92	25.55	22.84	23.60	25.26	24.40	25.08	18.05
	III	21.68	-135.53	16.38	17.75	18.86	21.84	7.82	12.36	24.38	22.42	22.07	21.71	8.56	19.37	20.23	21.14	21.98	18.38	19.39	21.60	20.45	21.36	12.01
	IV	24.64	-31.12	22.77	23.25	23.64	24.70	19.73	21.34	25.61	24.91	24.78	24.66	19.99	23.83	24.13	24.45	24.75	23.48	23.84	24.62	24.21	24.53	21.22
	Average	22.67	-136.20	17.32	18.71	19.82	22.84	8.67	13.26	25.41	23.43	23.07	22.71	9.42	20.34	21.21	22.13	22.98	19.35	20.37	22.60	21.44	22.35	12.90
9	I	13.16	-254.28	-26.24	-16.17	-7.82	13.39	-0.33	3.69	7.41	0.48	13.39	13.22	-56.76	0.17	5.40	9.81	13.42	-0.19	3.95	12.54	9.94	12.52	-10.42
	II	23.65	-80.20	8.35	12.25	15.50	23.73	18.41	19.97	21.41	18.72	23.73	23.67	-3.50	18.60	20.63	22.34	23.74	18.46	20.07	23.40	22.39	23.39	14.49
	III	19.12	-119.03	-1.24	3.96	8.28	19.23	12.15	14.22	16.14	12.57	19.23	19.14	-17.00	12.40	15.11	17.38	19.25	12.22	14.36	18.80	17.45	18.78	6.93
	IV	24.38	-24.62	17.16	19.01	20.54	24.42	21.91	22.65	23.33	22.06	24.42	24.39	11.57	22.00	22.96	23.77	24.43	21.94	22.69	24.27	23.79	24.26	20.06
	Average	20.08	-119.53	-0.49	4.76	9.13	20.19	13.04	15.13	17.07	13.46	20.19	20.11	-16.42	13.29	16.03	18.33	20.21	13.11	15.27	19.75	18.39	19.74	7.76

Table B.4. Nodal Hydraulic Pressure Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																						Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	8.42	-278.52	-30.51	-20.39	-12.18	3.57	-5.00	-1.10	2.57	9.84	-5.76	7.63	-50.97	0.53	3.53	7.20	10.72	-7.51	-2.33	8.45	-0.97	6.07	-15.76
	II	20.58	-90.83	5.46	9.40	12.58	18.70	15.37	16.89	18.31	21.13	15.08	20.27	-2.48	17.52	18.68	20.11	21.47	14.39	16.40	20.59	16.93	19.67	11.19
	III	15.70	-132.52	-4.41	0.82	5.06	13.19	8.77	10.79	12.68	16.43	8.38	15.29	-14.98	11.63	13.17	15.07	16.89	7.47	10.15	15.71	10.85	14.49	3.21
	IV	21.88	-30.70	14.75	16.60	18.11	20.99	19.42	20.14	20.81	22.14	19.28	21.74	11.00	20.43	20.98	21.66	22.30	18.96	19.91	21.88	20.16	21.45	17.45
	Average	16.65	-133.14	-3.68	1.61	5.89	14.11	9.64	11.68	13.59	17.39	9.25	16.23	-14.36	12.53	14.09	16.01	17.85	8.33	11.03	16.66	11.74	15.42	4.02
11	I	26.23	-6.91	20.00	21.44	22.68	25.99	23.85	24.51	25.15	25.13	25.66	26.18	-106.31	28.98	28.06	26.95	25.79	29.91	28.95	26.33	27.80	26.66	18.32
	II	28.11	15.24	25.69	26.25	26.73	28.01	27.18	27.44	27.69	27.68	27.88	28.09	-23.36	29.17	28.82	28.39	27.93	29.54	29.16	28.15	28.72	28.27	25.04
	III	25.38	8.27	22.17	22.91	23.55	25.26	24.15	24.50	24.83	24.81	25.09	25.36	-43.08	26.80	26.33	25.76	25.15	27.28	26.79	25.44	26.19	25.60	21.30
	IV	25.96	19.89	24.82	25.08	25.31	25.92	25.52	25.65	25.76	25.76	25.86	25.95	1.67	26.46	26.30	26.09	25.88	26.63	26.46	25.98	26.25	26.04	24.51
	Average	26.42	9.12	23.17	23.92	24.57	26.30	25.18	25.53	25.86	25.85	26.12	26.40	-42.77	27.85	27.38	26.80	26.19	28.34	27.84	26.48	27.24	26.64	22.29
12	I	19.28	-50.27	6.35	9.34	11.93	18.92	14.36	15.73	17.06	16.34	18.37	19.22	-106.07	-6.24	27.05	20.87	18.57	14.84	16.08	18.72	21.05	19.83	7.33
	II	25.41	-1.60	20.39	21.55	22.55	25.27	23.50	24.03	24.55	24.27	25.06	25.38	-23.26	15.50	28.42	26.03	25.13	23.68	24.17	25.19	26.10	25.62	20.77
	III	21.79	-14.13	15.12	16.66	18.00	21.61	19.25	19.96	20.65	20.28	21.32	21.76	-42.96	8.61	25.81	22.62	21.42	19.50	20.14	21.50	22.71	22.08	15.62
	IV	24.69	11.94	22.32	22.87	23.34	24.62	23.79	24.04	24.28	24.15	24.52	24.68	1.72	20.01	26.11	24.98	24.56	23.87	24.10	24.58	25.01	24.79	22.50
	Average	22.79	-13.52	16.05	17.61	18.96	22.61	20.23	20.94	21.64	21.26	22.32	22.76	-42.64	9.47	26.85	23.63	22.42	20.47	21.12	22.50	23.72	23.08	16.56
13	I	11.85	-110.74	-9.83	-4.72	-0.34	11.35	3.75	6.03	8.22	6.63	10.53	11.77	-104.49	-6.47	1.69	14.47	10.80	-3.32	0.96	10.47	13.87	12.55	-4.77
	II	21.30	-26.30	12.88	14.86	16.57	21.11	18.15	19.04	19.89	19.27	20.79	21.27	-23.87	14.19	17.35	22.32	20.89	15.41	17.07	20.76	22.08	21.57	14.85
	III	16.99	-46.34	5.79	8.43	10.69	16.73	12.80	13.98	15.12	14.29	16.31	16.95	-43.11	7.53	11.74	18.34	16.45	9.15	11.36	16.28	18.03	17.35	8.40
	IV	21.69	-0.77	17.72	18.65	19.46	21.60	20.21	20.63	21.03	20.74	21.45	21.68	0.37	18.33	19.83	22.17	21.50	18.91	19.70	21.44	22.06	21.82	18.65
	Average	17.96	-46.04	6.64	9.31	11.60	17.70	13.73	14.92	16.07	15.23	17.27	17.92	-42.78	8.40	12.65	19.33	17.41	10.04	12.27	17.24	19.01	18.32	9.28
14	I	5.93	-263.42	-32.12	-22.26	-14.17	1.44	-7.03	-3.21	0.35	6.60	-7.70	5.22	-67.94	-1.96	1.06	5.03	-3.76	-14.38	-7.38	6.13	-8.58	2.63	-19.07
	II	18.39	-86.19	3.62	7.44	10.59	16.65	13.36	14.84	16.22	18.65	13.10	18.11	-10.29	15.33	16.50	18.04	14.63	10.50	13.22	18.47	12.76	17.11	8.68
	III	13.45	-125.69	-6.21	-1.11	3.07	11.13	6.75	8.73	10.57	13.80	6.41	13.08	-24.71	9.37	10.93	12.98	8.44	2.96	6.57	13.55	5.95	11.75	0.53
	IV	19.79	-29.57	12.82	14.62	16.11	18.97	17.42	18.12	18.77	19.91	17.29	19.66	6.25	18.34	18.90	19.62	18.02	16.07	17.35	19.83	17.13	19.19	15.21
	Average	14.39	-126.22	-5.47	-0.33	3.90	12.05	7.63	9.62	11.48	14.74	7.28	14.02	-24.17	10.27	11.85	13.92	9.33	3.79	7.44	14.50	6.82	12.67	1.34
15	I	22.61	-38.52	11.29	13.92	16.18	22.09	18.31	19.51	20.67	21.03	21.42	22.51	-104.24	21.21	21.84	23.84	21.69	-15.89	30.46	23.27	26.26	23.59	11.05
	II	27.92	4.19	23.53	24.55	25.43	27.72	26.25	26.72	27.17	27.31	27.46	27.89	-21.33	27.38	27.63	28.40	27.57	12.98	30.97	28.18	29.34	28.30	23.43
	III	24.48	-7.10	18.63	19.99	21.16	24.21	22.26	22.88	23.48	23.66	23.86	24.43	-41.04	23.76	24.08	25.12	24.01	4.60	28.53	24.82	26.37	24.99	18.51
	IV	26.93	15.73	24.86	25.34	25.75	26.83	26.14	26.36	26.57	26.64	26.71	26.91	3.69	26.67	26.79	27.16	26.76	19.88	28.37	27.05	27.60	27.11	24.81
	Average	25.49	-6.43	19.58	20.95	22.13	25.21	23.24	23.87	24.47	24.66	24.86	25.44	-40.73	24.76	25.09	26.13	25.01	5.39	29.58	25.83	27.39	26.00	19.45
16	I	15.40	-93.88	-4.03	0.55	4.47	14.46	8.12	10.16	12.13	13.09	13.26	15.22	-103.51	7.44	10.58	17.40	13.76	-15.91	-4.47	16.91	22.08	17.20	-0.44
	II	24.51	-17.92	16.97	18.75	20.27	24.15	21.69	22.48	23.24	23.62	23.68	24.44	-21.65	21.42	22.64	25.29	23.88	12.36	16.80	25.10	27.11	25.21	18.37
	III	20.27	-36.18	10.24	12.60	14.63	19.79	16.51	17.57	18.58	19.08	19.17	20.18	-41.15	16.16	17.78	21.31	19.42	4.10	10.01	21.05	23.73	21.21	12.09
	IV	24.79	4.77	21.23	22.07	22.79	24.62	23.46	23.83	24.19	24.37	24.40	24.76	3.00	23.33	23.91	25.16	24.49	19.06	21.15	25.07	26.02	25.12	21.89
	Average	21.24	-35.80	11.10	13.49	15.54	20.76	17.45	18.51	19.54	20.04	20.13	21.15	-40.83	17.09	18.73	22.29	20.39	4.90	10.87	22.03	24.74	22.19	12.98
17	I	10.37	-143.74	-15.64	-9.37	-4.06	7.96	0.83	3.53	6.12	9.66	3.95	9.96	-100.82	2.44	5.52	11.16	5.62	-16.96	-6.15	11.31	-12.98	14.08	-9.42
	II	21.95	-37.89	11.85	14.28	16.35	21.01	18.24	19.29	20.30	21.67	19.45	21.79	-21.22	18.87	20.07	22.25	20.10	11.34	15.54	22.31	12.88	23.39	14.26
	III	17.19	-62.42	3.76	6.99	9.74	15.95	12.26	13.66	15.00	16.83	13.87	16.98	-40.25	13.10	14.69	17.60	14.74	3.07	8.66	17.68	5.13	19.11	6.97
	IV	23.05	-5.19	18.29	19.44	20.41	22.61	21.31	21.80	22.28	22.92	21.88	22.98	2.68	21.60	22.17	23.20	22.18	18.05	20.03	23.23	18.78	23.73	19.43
	Average	18.14	-62.31	4.57	7.84	10.61	16.88	13.16	14.57	15.93	17.77	14.79	17.93	-39.90	14.00	15.61	18.55	15.66	3.88	9.52	18.63	5.95	20.08	7.81

*) Refer to Table 4.11

Table B.5. Nodal Hydraulic Pressure Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																						Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	30.21	-193.48	33.10	32.54	32.01	30.36	31.49	31.16	30.83	30.81	30.55	30.24	19.42	28.28	29.00	29.76	30.47	27.45	28.31	30.15	29.17	29.95	19.63
	II	32.93	-53.93	34.05	33.83	33.62	32.98	33.42	33.29	33.16	33.16	33.05	32.94	28.73	32.18	32.46	32.75	33.02	31.85	32.19	32.90	32.52	32.82	28.81
	III	31.19	-84.36	32.68	32.39	32.12	31.27	31.85	31.68	31.51	31.50	31.36	31.21	25.61	30.19	30.57	30.96	31.32	29.76	30.21	31.16	30.65	31.06	25.72
	IV	32.45	-8.54	32.98	32.87	32.78	32.47	32.68	32.62	32.56	32.56	32.51	32.45	30.47	32.09	32.23	32.36	32.49	31.94	32.10	32.44	32.26	32.40	30.51
	Average	31.70	-85.08	33.20	32.91	32.63	31.77	32.36	32.19	32.02	32.01	31.87	31.71	26.06	30.69	31.07	31.46	31.83	30.25	30.70	31.66	31.15	31.56	26.17
3	I	26.38	-194.36	-10.42	31.39	30.50	26.60	24.77	25.25	25.68	27.27	26.88	26.42	10.09	23.49	24.58	25.70	26.76	22.25	23.54	26.29	24.82	25.99	13.63
	II	30.83	-54.88	16.54	32.77	32.43	30.91	30.20	30.39	30.55	31.17	31.02	30.84	24.50	29.70	30.13	30.56	30.97	29.22	29.72	30.79	30.22	30.68	25.88
	III	28.73	-85.30	9.72	31.31	30.86	28.84	27.90	28.14	28.37	29.19	28.98	28.75	20.32	27.24	27.80	28.38	28.93	26.59	27.26	28.68	27.92	28.53	22.14
	IV	30.93	-9.52	24.18	31.84	31.68	30.97	30.63	30.72	30.80	31.09	31.02	30.94	27.94	30.40	30.60	30.80	31.00	30.17	30.41	30.91	30.64	30.86	28.59
	Average	29.22	-86.02	10.01	31.83	31.37	29.33	28.38	28.63	28.85	29.68	29.48	29.24	20.71	27.71	28.28	28.86	29.42	27.06	27.73	29.17	28.40	29.02	22.56
4	I	23.09	-194.75	-11.22	-2.25	29.34	23.38	18.41	19.77	21.01	24.28	23.75	23.14	0.84	19.20	20.67	22.18	23.60	17.52	19.27	22.96	21.00	22.57	8.53
	II	28.94	-55.65	15.61	19.10	31.37	29.05	27.12	27.65	28.13	29.40	29.19	28.96	20.30	27.43	28.00	28.58	29.13	26.77	27.46	28.89	28.13	28.73	23.29
	III	26.55	-85.98	8.82	13.45	29.78	26.69	24.13	24.83	25.47	27.16	26.89	26.57	15.05	24.54	25.29	26.07	26.81	23.67	24.57	26.48	25.47	26.28	19.03
	IV	29.51	-10.41	23.22	24.86	30.65	29.56	28.65	28.90	29.13	29.73	29.63	29.52	25.43	28.80	29.06	29.34	29.60	28.49	28.81	29.48	29.12	29.41	26.84
	Average	27.02	-86.70	9.11	13.79	30.29	27.17	24.58	25.29	25.94	27.64	27.37	27.05	15.41	24.99	25.76	26.54	27.29	24.11	25.03	26.95	25.93	26.75	19.42
5	I	19.05	-192.99	-10.84	-2.91	3.43	19.46	8.72	11.74	14.50	20.74	19.99	19.13	-14.46	13.39	15.54	17.73	19.77	10.89	13.49	18.87	16.02	18.30	2.71
	II	26.76	-55.57	15.15	18.23	20.69	26.91	22.75	23.92	24.99	27.41	27.12	26.79	13.75	24.56	25.39	26.24	27.04	23.59	24.60	26.68	25.58	26.46	20.41
	III	23.98	-85.56	8.53	12.63	15.91	24.18	18.64	20.20	21.62	24.85	24.46	24.01	6.67	21.05	22.16	23.29	24.35	19.76	21.10	23.88	22.41	23.59	15.53
	IV	27.95	-10.90	22.47	23.93	25.09	28.03	26.06	26.61	27.12	28.26	28.12	27.96	21.81	26.91	27.31	27.71	28.08	26.46	26.93	27.92	27.40	27.81	24.96
	Average	24.44	-86.26	8.83	12.97	16.28	24.65	19.04	20.62	22.06	25.32	24.92	24.47	6.94	21.48	22.60	23.74	24.81	20.18	21.53	24.34	22.85	24.04	15.90
6	I	14.76	-195.21	-14.06	-6.34	-0.23	5.33	4.86	7.75	10.41	16.11	11.56	15.58	-22.12	9.10	11.26	13.68	16.04	5.15	8.23	14.69	10.08	13.56	-2.26
	II	23.87	-57.66	12.68	15.68	18.05	20.21	20.02	21.15	22.18	24.39	22.62	24.19	9.55	21.67	22.51	23.45	24.36	20.14	21.33	23.84	22.05	23.40	17.26
	III	20.79	-87.67	5.91	9.89	13.05	15.92	15.68	17.17	18.54	21.49	19.14	21.22	1.74	17.87	18.98	20.24	21.45	15.83	17.42	20.76	18.37	20.17	12.00
	IV	25.53	-12.94	20.25	21.67	22.78	23.80	23.72	24.25	24.73	25.78	24.94	25.68	18.77	24.49	24.89	25.33	25.77	23.77	24.33	25.52	24.67	25.31	22.41
	Average	21.24	-88.37	6.20	10.23	13.41	16.32	16.07	17.58	18.97	21.94	19.57	21.67	1.99	18.28	19.41	20.68	21.91	16.22	17.83	21.20	18.79	20.61	12.35
7	I	24.78	-197.49	24.72	24.87	24.94	24.95	2.74	27.04	26.41	25.50	25.18	24.81	11.88	22.47	23.33	24.23	25.09	21.47	22.51	24.70	23.53	24.47	12.82
	II	28.37	-57.93	28.35	28.41	28.43	28.44	19.81	29.25	29.00	28.65	28.52	28.38	23.36	27.47	27.81	28.16	28.49	27.09	27.49	28.34	27.88	28.25	23.73
	III	26.45	-88.36	26.42	26.50	26.53	26.54	15.07	27.62	27.30	26.82	26.66	26.47	19.79	25.26	25.70	26.17	26.61	24.74	25.28	26.41	25.81	26.29	20.28
	IV	28.18	-12.54	28.17	28.20	28.21	28.22	24.15	28.60	28.48	28.32	28.26	28.19	25.82	27.76	27.92	28.08	28.24	27.58	27.77	28.17	27.95	28.13	25.99
	Average	26.95	-89.08	26.92	27.00	27.03	27.04	15.44	28.13	27.80	27.32	27.16	26.96	20.21	25.74	26.19	26.66	27.11	25.22	25.76	26.91	26.29	26.79	20.71
8	I	23.32	-196.33	15.88	17.88	19.46	23.55	4.08	10.45	27.07	24.30	23.86	23.36	5.24	20.10	21.31	22.56	23.74	18.72	20.16	23.21	21.58	22.88	9.84
	II	28.41	-56.87	25.53	26.30	26.91	28.50	20.95	23.42	29.87	28.80	28.63	28.43	21.39	27.17	27.63	28.12	28.58	26.63	27.19	28.37	27.74	28.24	23.18
	III	26.18	-87.28	22.34	23.37	24.19	26.30	16.24	19.53	28.12	26.69	26.46	26.20	16.84	24.52	25.14	25.79	26.40	23.81	24.55	26.12	25.28	25.95	19.22
	IV	28.73	-11.51	27.37	27.74	28.03	28.78	25.21	26.38	29.42	28.91	28.83	28.74	25.42	28.14	28.37	28.59	28.81	27.89	28.15	28.71	28.42	28.65	26.26
	Average	26.66	-88.00	22.78	23.82	24.65	26.78	16.62	19.95	28.62	27.18	26.95	26.68	17.22	24.98	25.61	26.27	26.88	24.26	25.01	26.60	25.76	26.43	19.62
9	I	19.41	-173.40	-9.26	-1.70	4.46	19.58	9.70	12.62	15.24	10.80	19.60	19.45	-30.19	10.13	13.90	16.98	19.61	9.81	12.85	18.97	16.99	18.93	2.48
	II	27.51	-47.35	16.37	19.31	21.70	27.57	23.74	24.87	25.89	24.16	27.58	27.52	8.25	23.90	25.37	26.56	27.59	23.78	24.96	27.34	26.57	27.32	20.93
	III	24.64	-74.95	9.83	13.74	16.92	24.73	19.63	21.14	22.49	20.20	24.74	24.66	-0.98	19.85	21.80	23.39	24.75	19.69	21.26	24.42	23.40	24.40	15.90
	IV	28.83	-6.50	23.58	24.97	26.09	28.86	27.05	27.59	28.07	27.26	28.87	28.84	19.74	27.13	27.82	28.39	28.87	27.07	27.63	28.75	28.39	28.75	25.73
	Average	25.10	-75.55	10.13	14.08	17.29	25.19	20.03	21.56	22.92	20.61	25.20	25.12	-0.80	20.25	22.22	23.83	25.21	20.09	21.68	24.87	23.84	24.85	16.26

Table B.5. Nodal Hydraulic Pressure Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																						Average
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	15.38	-191.68	-12.95	-5.32	0.75	11.90	5.77	8.60	11.17	16.36	5.20	14.81	-26.88	9.70	11.87	14.48	17.00	3.89	7.70	15.40	8.50	13.70	-2.03
	II	24.72	-55.68	13.72	16.68	19.04	23.37	20.99	22.09	23.09	25.10	20.77	24.50	8.31	22.52	23.36	24.37	25.35	20.26	21.74	24.73	22.05	24.07	17.96
	III	21.59	-85.37	6.96	10.90	14.04	19.80	16.63	18.09	19.42	22.10	16.34	21.30	-0.24	18.66	19.78	21.13	22.43	15.66	17.63	21.60	18.04	20.73	12.60
	IV	26.46	-11.48	21.27	22.67	23.78	25.82	24.70	25.22	25.69	26.64	24.60	26.36	18.72	25.42	25.82	26.30	26.76	24.36	25.05	26.46	25.20	26.15	23.27
	Average	22.04	-86.05	7.25	11.23	14.40	20.22	17.02	18.50	19.84	22.55	16.73	21.74	-0.02	19.08	20.21	21.57	22.89	16.04	18.03	22.05	18.45	21.16	12.95
11	I	28.54	4.75	24.04	25.12	26.03	28.37	26.84	27.32	27.77	27.79	28.13	28.51	-65.46	30.51	29.84	29.06	28.23	31.17	30.48	28.62	29.68	28.84	22.92
	II	30.44	21.20	28.70	29.11	29.47	30.37	29.78	29.97	30.14	30.15	30.28	30.43	-6.06	31.20	30.95	30.64	30.32	31.46	31.19	30.47	30.88	30.56	28.26
	III	28.88	16.59	26.55	27.11	27.58	28.79	28.00	28.25	28.48	28.49	28.67	28.86	-19.68	29.89	29.55	29.15	28.72	30.24	29.88	28.92	29.47	29.03	25.97
	IV	29.69	25.33	28.87	29.06	29.23	29.66	29.38	29.47	29.55	29.55	29.62	29.68	12.47	30.05	29.93	29.79	29.63	30.17	30.04	29.70	29.90	29.75	28.66
	Average	29.39	16.97	27.04	27.60	28.08	29.30	28.50	28.75	28.99	29.00	29.18	29.37	-19.68	30.41	30.07	29.66	29.23	30.76	30.40	29.43	29.98	29.55	26.45
12	I	23.54	-26.48	14.19	16.42	18.33	23.29	20.02	21.02	21.95	21.54	22.89	23.50	-65.30	5.27	29.11	24.71	23.04	20.33	21.24	23.14	24.83	23.94	15.02
	II	28.50	9.08	24.87	25.74	26.48	28.40	27.13	27.52	27.88	27.72	28.25	28.48	-5.99	21.40	30.66	28.95	28.31	27.25	27.61	28.34	29.00	28.65	25.19
	III	26.30	0.46	21.46	22.62	23.60	26.16	24.48	24.99	25.47	25.26	25.96	26.27	-19.59	16.86	29.17	26.90	26.04	24.63	25.11	26.09	26.96	26.50	21.90
	IV	28.77	19.61	27.06	27.47	27.82	28.73	28.13	28.31	28.48	28.41	28.65	28.77	12.50	25.43	29.79	28.99	28.68	28.18	28.35	28.70	29.01	28.85	27.21
	Average	26.78	0.67	21.90	23.06	24.06	26.65	24.94	25.46	25.95	25.73	26.44	26.76	-19.60	17.24	29.68	27.39	26.52	25.10	25.58	26.57	27.45	26.99	22.33
13	I	17.67	-70.52	1.96	5.79	9.01	17.31	11.86	13.52	15.06	14.12	16.71	17.61	-64.77	4.55	10.42	19.58	16.93	6.73	9.86	16.68	19.12	18.17	5.79
	II	25.00	-9.24	18.90	20.38	21.64	24.86	22.74	23.38	23.98	23.62	24.63	24.97	-7.01	19.90	22.18	25.74	24.71	20.75	21.97	24.61	25.56	25.19	20.38
	III	22.29	-23.26	14.18	16.16	17.82	22.11	19.30	20.15	20.95	20.46	21.80	22.26	-20.29	15.52	18.55	23.28	21.91	16.64	18.26	21.78	23.05	22.55	16.16
	IV	26.06	9.90	23.19	23.89	24.48	26.00	25.00	25.30	25.59	25.41	25.89	26.05	10.96	23.66	24.74	26.41	25.93	24.06	24.63	25.88	26.33	26.16	23.89
	Average	22.76	-23.28	14.56	16.56	18.24	22.57	19.73	20.59	21.40	20.90	22.26	22.72	-20.28	15.91	18.97	23.75	22.37	17.05	18.68	22.24	23.52	23.02	16.55
14	I	13.04	-181.26	-14.64	-7.22	-1.24	9.81	3.74	6.52	9.02	13.53	3.24	12.53	-39.43	7.37	9.55	12.37	6.23	-1.58	3.55	13.18	2.42	10.69	-4.94
	II	22.59	-52.85	11.84	14.72	17.04	21.33	18.98	20.06	21.03	22.78	18.78	22.39	2.22	20.38	21.23	22.33	19.94	16.91	18.90	22.64	18.47	21.68	15.61
	III	19.42	-80.95	5.12	8.95	12.04	17.75	14.62	16.05	17.35	19.67	14.36	19.16	-7.68	16.49	17.62	19.07	15.90	11.87	14.52	19.49	13.94	18.21	10.14
	IV	24.40	-11.20	19.33	20.69	21.78	23.81	22.70	23.20	23.66	24.49	22.60	24.31	14.79	23.36	23.76	24.28	23.15	21.72	22.66	24.43	22.45	23.97	21.11
	Average	19.86	-81.57	5.41	9.29	12.41	18.18	15.01	16.46	17.77	20.12	14.75	19.60	-7.53	16.90	18.04	19.51	16.31	12.23	14.91	19.94	14.32	18.64	10.48
15	I	26.48	-17.51	18.28	20.25	21.92	26.11	23.40	24.27	25.08	25.39	25.62	26.41	-63.42	25.46	25.92	27.38	25.83	-1.31	32.11	26.95	29.15	27.18	18.23
	II	30.86	13.78	27.68	28.44	29.09	30.72	29.67	30.01	30.32	30.44	30.53	30.84	-4.04	30.47	30.65	31.21	30.61	20.07	33.05	31.05	31.90	31.14	27.66
	III	28.78	6.06	24.54	25.56	26.42	28.59	27.19	27.64	28.06	28.22	28.34	28.74	-17.66	28.25	28.49	29.25	28.45	14.42	31.69	29.03	30.16	29.14	24.52
	IV	30.95	22.89	29.44	29.80	30.11	30.88	30.38	30.54	30.69	30.75	30.79	30.93	14.47	30.76	30.84	31.11	30.83	25.85	31.98	31.03	31.43	31.07	29.43
	Average	29.27	6.31	24.99	26.01	26.89	29.08	27.66	28.12	28.54	28.70	28.82	29.23	-17.66	28.74	28.98	29.74	28.93	14.76	32.21	29.52	30.66	29.63	24.96
16	I	21.05	-57.58	6.98	10.41	13.30	20.38	15.84	17.32	18.70	19.46	19.52	20.93	-63.21	15.34	17.61	22.52	19.90	-1.58	6.83	22.13	25.92	22.34	9.73
	II	28.15	-2.39	22.68	24.01	25.13	27.88	26.12	26.70	27.23	27.53	27.55	28.10	-4.57	25.93	26.81	28.71	27.70	19.36	22.62	28.56	30.04	28.65	23.75
	III	25.49	-15.13	18.22	19.99	21.49	25.14	22.80	23.57	24.28	24.67	24.70	25.43	-18.03	22.54	23.71	26.25	24.90	13.80	18.15	26.05	28.01	26.16	19.65
	IV	29.13	14.73	26.56	27.18	27.71	29.01	28.18	28.45	28.70	28.84	28.85	29.11	13.69	28.09	28.50	29.40	28.92	24.99	26.53	29.33	30.03	29.37	27.06
	Average	25.96	-15.09	18.61	20.40	21.91	25.60	23.24	24.01	24.73	25.13	25.16	25.89	-18.03	22.98	24.16	26.72	25.36	14.14	18.53	26.52	28.50	26.63	20.05
17	I	17.07	-94.10	-1.85	2.87	6.80	15.33	10.21	12.18	14.01	16.59	12.43	16.77	-61.73	11.37	13.60	17.63	13.71	-2.63	5.30	17.73	-0.14	19.74	2.86
	II	25.99	-17.18	18.64	20.47	22.00	25.31	23.33	24.09	24.80	25.80	24.19	25.87	-4.61	23.78	24.64	26.21	24.68	18.34	21.42	26.24	19.31	27.02	20.47
	III	22.95	-34.47	13.18	15.61	17.65	22.05	19.41	20.43	21.37	22.70	20.55	22.80	-17.76	20.01	21.16	23.24	21.21	12.78	16.87	23.29	14.06	24.33	15.61
	IV	27.59	7.22	24.12	24.99	25.71	27.27	26.33	26.69	27.03	27.50	26.74	27.53	13.15	26.54	26.95	27.69	26.97	23.98	25.43	27.71	24.43	28.08	24.98
	Average	23.40	-34.63	13.52	15.99	18.04	22.49	19.82	20.85	21.80	23.15	20.98	23.24	-17.74	20.43	21.59	23.69	21.64	13.12	17.26	23.74	14.42	24.79	15.98

*) Refer to Table 4.11

Table C.1. Nodal Flow Under Average Demand During Various Demand Patterns

Node	Demand Pattern	Average Demand	State*																						Average
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	600	600	0	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	573
	II	360	360	0	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	344
	III	420	420	0	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	401
	IV	240	240	0	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	229
	Average	405	405	0	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	387
3	I	1,000	1,000	0	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	864
	II	600	600	0	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	573
	III	700	700	0	63	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	639
	IV	400	400	0	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	382
	Average	675	675	0	266	675	675	675	675	675	675	675	675	675	425	675	675	675	675	675	675	675	675	675	614
4	I	900	900	0	0	0	900	900	900	900	900	900	900	900	0	900	900	900	900	900	900	900	900	900	736
	II	540	540	0	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	515
	III	630	630	0	0	547	630	630	630	630	630	630	630	630	630	630	630	630	630	630	630	630	630	630	569
	IV	360	360	0	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	344
	Average	608	608	0	225	362	608	608	608	608	608	608	608	608	383	608	608	608	608	608	608	608	608	608	541
5	I	1,200	1,200	0	0	0	0	1,200	0	0	854	1,200	1,200	1,200	0	639	1,014	1,200	1,200	0	662	1,200	1,080	1,200	684
	II	720	720	0	691	720	720	720	720	720	720	720	720	720	576	720	720	720	720	720	720	720	720	720	679
	III	840	840	0	0	645	840	840	840	840	840	840	840	840	0	840	840	840	840	840	840	840	840	840	717
	IV	480	480	0	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	458
	Average	810	810	0	293	461	510	810	510	510	723	810	810	810	264	670	763	810	810	510	675	810	780	810	635
6	I	900	673	0	0	0	0	0	0	0	0	819	0	766	0	0	0	528	812	0	0	664	0	508	217
	II	540	540	0	352	540	540	540	540	540	540	540	540	540	0	540	540	540	540	540	540	540	540	540	482
	III	630	630	0	0	129	517	630	630	630	630	630	630	630	0	630	630	630	630	630	630	630	630	630	516
	IV	360	360	0	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	344
	Average	608	551	0	178	257	354	383	383	383	383	587	383	574	90	383	383	514	585	383	383	548	383	509	390
7	I	800	800	0	800	800	800	800	0	800	800	800	800	800	0	800	800	800	800	800	800	800	800	800	691
	II	480	480	0	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	458
	III	560	560	0	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	535
	IV	320	320	0	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	305
	Average	540	540	0	540	540	540	540	340	540	540	540	540	540	340	540	540	540	540	540	540	540	540	540	497
8	I	800	800	0	708	800	800	800	0	0	800	800	800	800	0	800	800	800	800	800	800	800	800	800	650
	II	480	480	0	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	458
	III	560	560	0	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	535
	IV	320	320	0	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	305
	Average	540	540	0	517	540	540	540	340	340	540	540	540	540	340	540	540	540	540	540	540	540	540	540	487
9	I	1,200	1,200	0	0	0	0	1,200	0	436	972	0	1,200	1,200	0	0	746	1,200	1,200	0	503	1,200	1,200	1,200	612
	II	720	720	0	720	720	720	720	720	720	720	720	720	720	0	720	720	720	720	720	720	720	720	720	655
	III	840	840	0	145	757	840	840	840	840	840	840	840	840	0	840	840	840	840	840	840	840	840	840	728
	IV	480	480	0	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	458
	Average	810	810	0	336	489	510	810	510	619	753	510	810	810	120	510	696	810	810	510	636	810	810	810	613
10	I	1,200	991	0	0	0	0	0	0	0	0	1,126	0	904	0	0	0	852	1,200	0	0	994	0	706	308
	II	720	720	0	573	720	720	720	720	720	720	720	720	720	0	720	720	720	720	720	720	720	720	720	648
	III	840	840	0	0	415	784	840	840	840	840	840	840	840	0	840	840	840	840	840	840	840	840	840	704
	IV	480	480	0	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	458
	Average	810	758	0	263	404	496	510	510	510	510	791	510	736	120	510	510	723	810	510	510	758	510	686	529

Table C.1. Nodal Flow Under Average Demand During Various Demand Patterns

Node	Demand Pattern	Average Demand	State*																						Average
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
11	I	600	600	0	600	600	600	600	600	600	600	600	600	600	0	600	600	600	600	600	600	600	600	600	545
	II	360	360	360	360	360	360	360	360	360	360	360	360	360	0	360	360	360	360	360	360	360	360	360	344
	III	420	420	420	420	420	420	420	420	420	420	420	420	420	0	420	420	420	420	420	420	420	420	420	401
	IV	240	240	240	240	240	240	240	240	240	240	240	240	240	209	240	240	240	240	240	240	240	240	240	239
	Average	405	405	255	405	405	405	405	405	405	405	405	405	405	52	405	405	405	405	405	405	405	405	405	382
12	I	800	800	0	533	756	800	800	800	800	800	800	800	800	0	0	800	800	800	800	800	800	800	800	677
	II	480	480	0	480	480	480	480	480	480	480	480	480	480	0	480	480	480	480	480	480	480	480	480	436
	III	560	560	0	560	560	560	560	560	560	560	560	560	560	0	560	560	560	560	560	560	560	560	560	509
	IV	320	320	320	320	320	320	320	320	320	320	320	320	320	279	320	320	320	320	320	320	320	320	320	318
	Average	540	540	80	473	529	540	540	540	540	540	540	540	540	70	340	540	540	540	540	540	540	540	540	485
13	I	1,200	1,200	0	0	0	0	1,200	0	668	943	787	1,170	1,200	0	0	0	1,200	1,195	0	0	1,165	1,200	1,200	597
	II	720	720	0	720	720	720	720	720	720	720	720	720	720	0	720	720	720	720	720	720	720	720	720	655
	III	840	840	0	797	840	840	840	840	840	840	840	840	840	0	840	840	840	840	840	840	840	840	840	762
	IV	480	480	237	480	480	480	480	480	480	480	480	480	480	324	480	480	480	480	480	480	480	480	400	458
	Average	810	810	59	499	510	510	810	510	677	746	707	802	810	81	510	510	810	809	510	510	801	810	790	618
14	I	800	372	0	0	0	0	0	0	0	0	447	0	268	0	0	0	226	0	0	0	394	0	0	78
	II	480	480	0	244	438	480	480	480	480	480	480	480	480	0	480	480	480	480	480	480	480	480	480	424
	III	560	560	0	0	0	385	560	557	560	560	560	542	560	0	560	560	560	560	371	551	560	517	560	438
	IV	320	320	0	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	305
	Average	540	433	0	141	190	296	340	339	340	340	452	335	407	80	340	340	397	340	293	338	438	329	340	311
15	I	800	800	0	800	800	800	800	800	800	800	800	800	800	0	800	800	800	800	0	800	800	800	800	691
	II	480	480	386	480	480	480	480	480	480	480	480	480	480	0	480	480	480	480	480	480	480	480	480	454
	III	560	560	0	560	560	560	560	560	560	560	560	560	560	0	560	560	560	560	545	560	560	560	560	508
	IV	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320
	Average	540	540	177	540	540	540	540	540	540	540	540	540	540	80	540	540	540	540	336	540	540	540	540	493
16	I	600	600	0	0	0	309	600	529	600	600	600	600	600	0	493	600	600	600	0	0	600	600	600	415
	II	360	360	0	360	360	360	360	360	360	360	360	360	360	0	360	360	360	360	360	360	360	360	360	327
	III	420	420	0	420	420	420	420	420	420	420	420	420	420	0	420	420	420	420	381	420	420	420	420	380
	IV	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240
	Average	405	405	60	255	255	332	405	387	405	405	405	405	405	60	378	405	405	405	245	255	405	405	405	341
17	I	900	900	0	0	0	0	738	0	189	575	866	273	882	0	0	514	900	531	0	0	900	0	900	371
	II	540	540	0	540	540	540	540	540	540	540	540	540	540	0	540	540	540	540	540	540	540	540	540	491
	III	630	630	0	527	630	630	630	630	630	630	630	630	630	0	630	630	630	630	496	630	630	590	630	560
	IV	360	360	0	360	360	360	360	360	360	360	360	360	360	340	360	360	360	360	360	360	360	360	360	343
	Average	608	608	0	357	383	383	567	383	430	526	599	451	603	85	383	511	608	515	349	383	608	372	608	441
Sum	I	14,300	13,436	0	4,041	5,356	6,609	11,238	5,229	7,393	10,244	12,144	10,743	13,320	600	6,633	9,173	13,006	13,038	5,500	7,465	13,416	10,380	12,613	8,708
	II	8,580	8,580	746	7,980	8,538	8,580	8,580	8,580	8,580	8,580	8,580	8,580	8,580	3,036	8,580	8,580	8,580	8,580	8,580	8,580	8,580	8,580	8,580	7,943
	III	10,010	10,010	420	5,032	8,163	9,666	10,010	10,007	10,010	10,010	10,010	9,992	10,010	2,870	10,010	10,010	10,010	10,010	9,633	10,001	10,010	9,927	10,010	8,901
	IV	5,720	5,720	1,357	5,720	5,720	5,720	5,720	5,720	5,720	5,720	5,720	5,720	5,720	5,472	5,720	5,720	5,720	5,720	5,720	5,720	5,720	5,720	5,640	5,507
	Average	9,653	9,437	631	5,693	6,944	7,644	8,887	7,384	7,926	8,638	9,114	8,759	9,407	2,995	7,736	8,371	9,329	9,337	7,358	7,942	9,431	8,652	9,211	7,765
Volume Reliability	I		0.940	0.000	0.283	0.375	0.462	0.786	0.366	0.517	0.716	0.849	0.751	0.931	0.042	0.464	0.641	0.910	0.912	0.385	0.522	0.938	0.726	0.882	0.609
	II		1.000	0.087	0.930	0.995	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.354	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.926
	III		1.000	0.042	0.503	0.816	0.966	1.000	1.000	1.000	1.000	1.000	0.998	1.000	0.287	1.000	1.000	1.000	1.000	0.962	0.999	1.000	0.992	1.000	0.889
	IV		1.000	0.237	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.957	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.986	0.963
	Average		0.985	0.092	0.679	0.796	0.857	0.946	0.841	0.879	0.929	0.962	0.937	0.983	0.410	0.866	0.910	0.977	0.978	0.837	0.880	0.985	0.929	0.967	0.847

*) Refer to Table 4.11

Table C.2. Nodal Flow Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	Maximum Demand	State*																						Average
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	745	745	0	745	745	745	745	745	745	745	745	745	745	235	745	745	745	745	745	745	745	745	745	688
	II	447	447	0	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	426
	III	521	521	0	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	497
	IV	298	298	0	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	284
	Average	503	503	0	503	503	503	503	503	503	503	503	503	503	375	503	503	503	503	503	503	503	503	503	474
3	I	1,145	1,145	0	0	1,145	1,145	1,145	1,145	1,145	1,145	1,145	1,145	1,145	0	1,145	1,145	1,145	1,145	1,145	1,145	1,145	1,145	1,145	988
	II	687	687	0	0	687	687	687	687	687	687	687	687	687	687	687	687	687	687	687	687	687	687	687	624
	III	801	801	0	0	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	728
	IV	458	458	0	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	437
	Average	773	773	0	114	773	773	773	773	773	773	773	773	773	486	773	773	773	773	773	773	773	773	773	695
4	I	1,045	1,045	0	0	0	1,045	1,045	124	649	899	1,045	1,045	1,045	0	507	836	1,045	1,045	0	522	1,045	901	1,045	676
	II	627	627	0	0	478	627	627	627	627	627	627	627	627	596	627	627	627	627	627	627	627	627	627	562
	III	731	731	0	0	0	731	731	731	731	731	731	731	731	0	731	731	731	731	731	731	731	731	731	598
	IV	418	418	0	418	418	418	418	418	418	418	418	418	418	418	418	418	418	418	418	418	418	418	418	399
	Average	705	705	0	104	224	705	705	475	606	669	705	705	705	253	571	653	705	705	444	574	705	669	705	559
5	I	1,417	714	0	0	0	0	857	0	0	0	1,224	1,018	742	0	0	0	0	959	0	0	637	0	290	293
	II	850	850	0	0	550	850	850	850	850	850	850	850	850	0	850	850	850	850	850	850	850	850	850	720
	III	992	992	0	0	0	0	992	870	992	992	992	992	992	0	992	992	992	992	992	992	992	992	992	761
	IV	567	567	0	567	567	567	567	567	567	567	567	567	567	567	567	567	567	567	567	567	567	567	567	541
	Average	956	781	0	142	279	354	816	572	602	602	908	857	788	142	602	602	602	842	602	602	761	602	675	579
6	I	1,077	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	II	646	646	0	0	0	458	646	646	646	646	646	646	646	0	646	646	646	646	646	646	646	646	646	520
	III	754	754	0	0	0	0	311	238	539	716	754	754	754	0	637	754	754	754	294	576	754	702	754	491
	IV	431	431	0	431	431	431	431	431	431	431	431	431	431	431	431	431	431	431	431	431	431	431	431	411
	Average	727	458	0	108	108	222	347	329	404	448	458	458	458	108	428	458	458	458	343	413	458	445	458	356
7	I	945	945	0	945	945	945	945	0	945	945	945	945	945	0	945	945	945	945	945	945	945	945	945	816
	II	567	567	0	567	567	567	567	547	567	567	567	567	567	567	567	567	567	567	567	567	567	567	567	540
	III	661	661	0	661	661	661	661	0	661	661	661	661	661	661	661	661	661	661	661	661	661	661	661	601
	IV	378	378	0	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	361
	Average	638	638	0	638	638	638	638	231	638	638	638	638	638	401	638	638	638	638	638	638	638	638	638	579
8	I	977	977	0	0	0	571	977	0	0	977	977	977	977	0	719	913	977	977	391	726	977	957	977	638
	II	586	586	0	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	559
	III	684	684	0	684	684	684	684	212	684	684	684	684	684	339	684	684	684	684	684	684	684	684	684	616
	IV	391	391	0	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	373
	Average	659	659	0	415	415	558	659	297	415	659	659	659	659	329	595	643	659	659	513	597	659	654	659	547
9	I	1,465	744	0	0	0	0	805	0	0	0	0	805	759	0	0	0	0	813	0	0	532	0	524	226
	II	879	879	0	0	701	879	879	879	879	879	879	879	879	0	879	879	879	879	879	879	879	879	879	751
	III	1,026	1,026	0	0	0	445	1,026	1,007	1,026	1,026	1,026	1,026	1,026	0	1,026	1,026	1,026	1,026	1,013	1,026	1,026	1,026	1,026	811
	IV	586	586	0	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	586	559
	Average	989	809	0	147	322	477	824	618	623	623	623	824	812	147	623	623	623	826	620	623	756	623	754	587
10	I	1,425	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	II	855	855	0	0	216	716	855	855	855	855	855	855	855	0	855	855	855	855	855	855	855	855	855	703
	III	997	997	0	0	0	0	997	535	828	997	997	455	997	0	924	997	997	997	167	748	997	837	997	658
	IV	570	570	0	570	570	570	570	570	570	570	570	570	570	570	570	570	570	570	570	570	570	570	570	544
	Average	962	606	0	142	197	322	606	490	563	606	606	470	606	142	587	606	606	606	398	543	606	565	606	476

Table C.2. Nodal Flow Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	Maximum Demand	State*																						Average
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
11	I	777	777	0	777	777	777	777	777	777	777	777	777	777	0	777	777	777	777	777	777	777	777	777	706
	II	466	466	466	466	466	466	466	466	466	466	466	466	466	0	466	466	466	466	466	466	466	466	466	445
	III	544	544	235	544	544	544	544	544	544	544	544	544	544	0	544	544	544	544	544	544	544	544	544	505
	IV	311	311	311	311	311	311	311	311	311	311	311	311	311	0	311	311	311	311	311	311	311	311	311	297
	Average	524	524	253	524	524	524	524	524	524	524	524	524	524	0	524	524	524	524	524	524	524	524	524	488
12	I	950	950	0	0	0	95	950	670	835	950	898	950	950	0	0	950	950	950	731	872	950	950	950	661
	II	570	570	0	570	570	570	570	570	570	570	570	570	570	0	570	570	570	570	570	570	570	570	570	518
	III	665	665	0	665	665	665	665	665	665	665	665	665	665	0	336	665	665	665	665	665	665	665	665	590
	IV	380	380	380	380	380	380	380	380	380	380	380	380	380	0	380	380	380	380	380	380	380	380	380	363
	Average	641	641	95	404	404	427	641	571	612	641	628	641	641	0	322	641	641	641	586	622	641	641	641	533
13	I	1,453	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,048	0	0	0	0	917	536	114
	II	872	872	0	760	872	872	872	872	872	872	872	872	872	0	872	872	872	872	872	872	872	872	872	788
	III	1,017	1,017	0	0	475	834	1,017	1,017	1,017	1,017	1,017	1,017	1,017	0	198	955	1,017	1,017	614	913	1,017	1,017	1,017	783
	IV	581	581	0	581	581	581	581	581	581	581	581	581	581	0	581	581	581	581	581	581	581	581	458	523
	Average	981	618	0	335	482	572	618	618	618	618	618	618	618	0	413	602	880	618	517	592	618	847	721	552
14	I	969	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	II	581	581	0	0	0	319	581	538	581	581	581	521	581	0	581	581	581	581	311	529	581	499	581	441
	III	678	678	0	0	0	0	590	0	358	545	678	0	678	0	433	576	678	320	0	0	678	0	637	311
	IV	388	388	0	388	388	388	388	388	388	388	388	388	388	164	388	388	388	388	388	388	388	388	388	360
	Average	654	412	0	97	97	177	390	231	332	379	412	227	412	41	351	386	412	322	175	229	412	222	401	278
15	I	935	935	0	0	597	867	935	935	935	935	935	935	935	0	935	935	935	935	0	935	935	935	935	747
	II	561	561	0	561	561	561	561	561	561	561	561	561	561	0	561	561	561	561	496	561	561	561	561	507
	III	655	655	0	655	655	655	655	655	655	655	655	655	655	0	655	655	655	655	0	655	655	655	655	565
	IV	374	374	374	374	374	374	374	374	374	374	374	374	374	0	374	374	374	374	374	374	374	374	374	357
	Average	631	631	94	397	547	614	631	631	631	631	631	631	631	0	631	631	631	631	217	631	631	631	631	544
16	I	750	629	0	0	0	0	539	0	0	168	369	394	614	0	0	0	750	460	0	0	750	750	750	281
	II	450	450	0	450	450	450	450	450	450	450	450	450	450	0	450	450	450	450	364	450	450	450	450	405
	III	525	525	0	400	525	525	525	525	525	525	525	525	525	0	525	525	525	525	0	384	525	525	525	441
	IV	300	300	0	300	300	300	300	300	300	300	300	300	300	0	300	300	300	300	300	300	300	300	300	273
	Average	506	476	0	287	319	319	453	319	319	361	411	417	472	0	319	319	506	434	166	283	506	506	506	350
17	I	1,050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	696	32
	II	630	630	0	469	630	630	630	630	630	630	630	630	630	0	630	630	630	630	424	630	630	550	630	552
	III	735	735	0	0	0	510	735	730	735	735	735	735	735	0	735	735	735	735	0	378	735	0	735	508
	IV	420	420	0	420	420	420	420	420	420	420	420	420	420	0	420	420	420	420	420	420	420	420	420	382
	Average	709	446	0	222	262	390	446	445	446	446	446	446	446	0	446	446	446	446	211	357	446	242	620	368
Sum	I	17,122	9,604	0	2,466	4,208	6,188	9,718	4,395	6,029	7,538	9,058	9,734	9,631	235	5,772	7,244	9,315	9,749	4,732	6,665	9,436	9,020	10,314	6,866
	II	10,273	10,273	466	4,876	7,780	9,685	10,273	10,210	10,273	10,273	10,273	10,213	10,273	2,882	10,273	10,273	10,273	10,273	9,646	10,221	10,273	10,111	10,273	9,062
	III	11,986	11,986	235	4,129	5,530	7,576	11,455	9,052	11,282	11,815	11,986	10,765	11,986	2,323	10,403	11,821	11,986	11,627	7,687	10,277	11,986	10,360	11,944	9,464
	IV	6,849	6,849	1,065	6,849	6,849	6,849	6,849	6,849	6,849	6,849	6,849	6,849	6,849	4,259	6,849	6,849	6,849	6,849	6,849	6,849	6,849	6,849	6,725	6,463
	Average	11,558	9,678	441	4,580	6,092	7,574	9,574	7,626	8,608	9,119	9,541	9,390	9,685	2,425	8,324	9,047	9,606	9,624	7,228	8,503	9,636	9,085	9,814	7,964
Volume Reliability	I		0.561	0.000	0.144	0.246	0.361	0.568	0.257	0.352	0.440	0.529	0.568	0.562	0.014	0.337	0.423	0.544	0.569	0.276	0.389	0.551	0.527	0.602	0.401
	II		1.000	0.045	0.475	0.757	0.943	1.000	0.994	1.000	1.000	1.000	0.994	1.000	0.281	1.000	1.000	1.000	1.000	0.939	0.995	1.000	0.984	1.000	0.882
	III		1.000	0.020	0.345	0.461	0.632	0.956	0.755	0.941	0.986	1.000	0.898	1.000	0.194	0.868	0.986	1.000	0.970	0.641	0.857	1.000	0.864	0.997	0.790
	IV		1.000	0.155	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.622	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.982	0.944
	Average		0.890	0.055	0.491	0.616	0.734	0.881	0.751	0.823	0.856	0.882	0.865	0.891	0.277	0.801	0.852	0.886	0.885	0.714	0.810	0.888	0.844	0.895	0.754

*) Refer to Table 4.11

Table C.3. Nodal Flow Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	Minimum Demand	State*																						Average
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	423	423	0	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	423	404
	II	254	254	0	254	254	254	254	254	254	254	254	254	254	254	254	254	254	254	254	254	254	254	254	242
	III	296	296	0	296	296	296	296	296	296	296	296	296	296	296	296	296	296	296	296	296	296	296	296	283
	IV	169	169	0	169	169	169	169	169	169	169	169	169	169	169	169	169	169	169	169	169	169	169	169	162
	Average	286	286	0	286	286	286	286	286	286	286	286	286	286	286	286	286	286	286	286	286	286	286	286	273
3	I	823	823	0	0	823	823	823	823	823	823	823	823	823	823	823	823	823	823	823	823	823	823	823	748
	II	494	494	0	494	494	494	494	494	494	494	494	494	494	494	494	494	494	494	494	494	494	494	494	471
	III	576	576	0	576	576	576	576	576	576	576	576	576	576	576	576	576	576	576	576	576	576	576	576	550
	IV	329	329	0	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	314
	Average	556	556	0	350	556	556	556	556	556	556	556	556	556	556	556	556	556	556	556	556	556	556	556	521
4	I	723	723	0	0	0	723	723	723	723	723	723	723	723	129	723	723	723	723	723	723	723	723	723	598
	II	434	434	0	434	434	434	434	434	434	434	434	434	434	434	434	434	434	434	434	434	434	434	434	414
	III	506	506	0	506	506	506	506	506	506	506	506	506	506	506	506	506	506	506	506	506	506	506	506	483
	IV	289	289	0	289	289	289	289	289	289	289	289	289	289	289	289	289	289	289	289	289	289	289	289	276
	Average	488	488	0	307	307	488	488	488	488	488	488	488	488	340	488	488	488	488	488	488	488	488	488	443
5	I	935	935	0	0	0	507	935	935	935	935	935	935	935	0	935	935	935	935	935	935	935	935	935	745
	II	561	561	0	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	561	535
	III	654	654	0	654	654	654	654	654	654	654	654	654	654	654	654	654	654	654	654	654	654	654	654	625
	IV	374	374	0	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	357
	Average	631	631	0	397	397	524	631	631	631	631	631	631	631	397	631	631	631	631	631	631	631	631	631	566
6	I	742	742	0	0	0	0	448	445	636	742	742	742	742	0	710	742	742	742	451	666	742	742	742	523
	II	445	445	0	445	445	445	445	445	445	445	445	445	445	445	445	445	445	445	445	445	445	445	445	425
	III	519	519	0	461	519	519	519	519	519	519	519	519	519	257	519	519	519	519	519	519	519	519	519	481
	IV	297	297	0	297	297	297	297	297	297	297	297	297	297	297	297	297	297	297	297	297	297	297	297	283
	Average	501	501	0	301	315	315	427	427	474	501	501	501	501	250	493	501	501	501	428	482	501	501	501	428
7	I	623	623	0	623	623	623	623	266	623	623	623	623	623	623	623	623	623	623	623	623	623	623	623	579
	II	374	374	0	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	357
	III	436	436	0	436	436	436	436	436	436	436	436	436	436	436	436	436	436	436	436	436	436	436	436	416
	IV	249	249	0	249	249	249	249	249	249	249	249	249	249	249	249	249	249	249	249	249	249	249	249	238
	Average	421	421	0	421	421	421	421	331	421	421	421	421	421	421	421	421	421	421	421	421	421	421	421	397
8	I	642	642	0	642	642	642	642	418	642	642	642	642	642	483	642	642	642	642	642	642	642	642	642	595
	II	385	385	0	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	368
	III	449	449	0	449	449	449	449	449	449	449	449	449	449	449	449	449	449	449	449	449	449	449	449	429
	IV	257	257	0	257	257	257	257	257	257	257	257	257	257	257	257	257	257	257	257	257	257	257	257	245
	Average	433	433	0	433	433	433	433	377	433	433	433	433	433	393	433	433	433	433	433	433	433	433	433	409
9	I	963	963	0	0	0	679	963	963	963	963	963	963	963	0	963	963	963	963	963	963	963	963	963	775
	II	578	578	0	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	551
	III	674	674	0	674	674	674	674	674	674	674	674	674	674	195	674	674	674	674	674	674	674	674	674	622
	IV	385	385	0	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	368
	Average	650	650	0	409	409	579	650	650	650	650	650	650	650	290	650	650	650	650	650	650	650	650	650	579
10	I	1,001	1,001	0	0	0	0	1,001	740	956	1,001	1,001	639	1,001	0	1,001	1,001	1,001	1,001	507	892	1,001	933	1,001	713
	II	601	601	0	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	601	573
	III	701	701	0	699	701	701	701	701	701	701	701	701	701	140	701	701	701	701	701	701	701	701	701	643
	IV	400	400	0	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	382
	Average	676	676	0	425	425	425	676	610	665	676	676	585	676	285	676	676	676	676	552	649	676	659	676	578

Table C.3. Nodal Flow Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	Minimum Demand	State*																						Average
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
11	I	442	442	317	442	442	442	442	442	442	442	442	442	442	0	442	442	442	442	442	442	442	442	442	416
	II	265	265	265	265	265	265	265	265	265	265	265	265	265	0	265	265	265	265	265	265	265	265	265	253
	III	309	309	309	309	309	309	309	309	309	309	309	309	309	0	309	309	309	309	309	309	309	309	309	295
	IV	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177
	Average	298	298	267	298	298	298	298	298	298	298	298	298	298	44	298	298	298	298	298	298	298	298	298	285
12	I	667	667	0	667	667	667	667	667	667	667	667	667	667	0	485	667	667	667	667	667	667	667	667	598
	II	400	400	400	400	400	400	400	400	400	400	400	400	400	0	400	400	400	400	400	400	400	400	400	382
	III	467	467	228	467	467	467	467	467	467	467	467	467	467	0	467	467	467	467	467	467	467	467	467	435
	IV	267	267	267	267	267	267	267	267	267	267	267	267	267	267	267	267	267	267	267	267	267	267	267	267
	Average	451	451	224	451	451	451	451	451	451	451	451	451	451	67	405	451	451	451	451	451	451	451	451	421
13	I	947	947	0	0	656	905	947	947	947	947	947	947	947	0	529	947	947	947	731	947	947	947	947	774
	II	568	568	0	568	568	568	568	568	568	568	568	568	568	0	568	568	568	568	568	568	568	568	568	516
	III	663	663	0	663	663	663	663	663	663	663	663	663	663	0	663	663	663	663	663	663	663	663	663	602
	IV	379	379	379	379	379	379	379	379	379	379	379	379	379	379	379	379	379	379	379	379	379	379	379	379
	Average	639	639	95	402	566	629	639	639	639	639	639	639	639	95	535	639	639	639	585	639	639	639	639	568
14	I	631	631	0	0	0	0	609	239	447	578	631	80	631	0	494	604	631	434	0	205	631	0	631	340
	II	379	379	0	379	379	379	379	379	379	379	379	379	379	133	379	379	379	379	379	379	379	379	379	350
	III	442	442	0	347	442	442	442	442	442	442	442	442	442	0	442	442	442	442	442	442	442	442	442	397
	IV	252	252	0	252	252	252	252	252	252	252	252	252	252	252	252	252	252	252	252	252	252	252	252	241
	Average	426	426	0	244	268	268	420	328	380	413	426	288	426	96	392	419	426	377	268	320	426	268	426	332
15	I	678	678	0	678	678	678	678	678	678	678	678	678	678	0	678	678	678	678	0	678	678	678	678	585
	II	407	407	407	407	407	407	407	407	407	407	407	407	407	0	407	407	407	407	407	407	407	407	407	388
	III	474	474	474	474	474	474	474	474	474	474	474	474	474	0	474	474	474	474	474	474	474	474	474	453
	IV	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271	271
	Average	457	457	288	457	457	457	457	457	457	457	457	457	457	68	457	457	457	457	288	457	457	457	457	424
16	I	467	467	0	422	467	467	467	467	467	467	467	467	467	0	467	467	467	467	0	420	467	467	467	399
	II	280	280	0	280	280	280	280	280	280	280	280	280	280	0	280	280	280	280	280	280	280	280	280	255
	III	327	327	0	327	327	327	327	327	327	327	327	327	327	0	327	327	327	327	327	327	327	327	327	297
	IV	187	187	187	187	187	187	187	187	187	187	187	187	187	187	187	187	187	187	187	187	187	187	187	187
	Average	316	316	47	304	316	316	316	316	316	316	316	316	316	47	316	316	316	316	199	304	316	316	316	285
17	I	767	767	0	0	324	647	767	767	767	767	767	767	767	0	767	767	767	767	0	557	767	0	767	558
	II	460	460	0	460	460	460	460	460	460	460	460	460	460	0	460	460	460	460	460	460	460	460	460	419
	III	537	537	0	537	537	537	537	537	537	537	537	537	537	0	537	537	537	537	537	537	537	537	537	488
	IV	307	307	307	307	307	307	307	307	307	307	307	307	307	307	307	307	307	307	307	307	307	307	307	307
	Average	518	518	77	326	407	488	518	518	518	518	518	518	518	77	518	518	518	518	326	465	518	326	518	443
Sum	I	11,474	11,474	317	3,897	5,745	8,227	11,158	9,944	11,140	11,421	11,474	10,562	11,474	2,482	10,705	11,447	11,474	11,278	7,930	10,606	11,474	10,008	11,474	9,351
	II	6,885	6,885	1,072	6,885	6,885	6,885	6,885	6,885	6,885	6,885	6,885	6,885	6,885	4,258	6,885	6,885	6,885	6,885	6,885	6,885	6,885	6,885	6,885	6,501
	III	8,032	8,032	1,011	7,877	8,032	8,032	8,032	8,032	8,032	8,032	8,032	8,032	8,032	3,511	8,032	8,032	8,032	8,032	8,032	8,032	8,032	8,032	8,032	7,500
	IV	4,590	4,590	1,587	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,590	4,453
	Average	7,745	7,745	997	5,812	6,313	6,933	7,666	7,363	7,662	7,732	7,745	7,517	7,745	3,710	7,553	7,738	7,745	7,696	6,859	7,528	7,745	7,379	7,745	6,951
Volume Reliability	I		1.000	0.028	0.340	0.501	0.717	0.972	0.867	0.971	0.995	1.000	0.920	1.000	0.216	0.933	0.998	1.000	0.983	0.691	0.924	1.000	0.872	1.000	0.815
	II		1.000	0.156	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.619	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.944
	III		1.000	0.126	0.981	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.437	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.934
	IV		1.000	0.346	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.970
	Average		1.000	0.164	0.830	0.875	0.929	0.993	0.967	0.993	0.999	1.000	0.980	1.000	0.568	0.983	0.999	1.000	0.996	0.923	0.981	1.000	0.968	1.000	0.916

*) Refer to Table 4.11

Table C.4. Nodal Flow Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	Maximum Demand	State*																						Average
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	745	745	0	745	745	745	745	745	745	745	745	745	745	205	745	745	745	745	745	745	745	745	745	686
	II	447	447	0	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	447	426
	III	521	521	0	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	521	497
	IV	298	298	0	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	298	284
	Average	503	503	0	503	503	503	503	503	503	503	503	503	503	368	503	503	503	503	503	503	503	503	503	474
3	I	1,145	1,145	0	0	1,145	1,145	1,145	1,145	1,145	1,145	1,145	1,145	1,145	0	1,145	1,145	1,145	1,145	1,135	1,145	1,145	1,145	1,145	988
	II	687	687	0	0	687	687	687	687	687	687	687	687	687	687	687	687	687	687	687	687	687	687	687	624
	III	801	801	0	0	801	801	801	801	801	801	801	801	801	304	801	801	801	801	801	801	801	801	801	706
	IV	458	458	0	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	458	437
	Average	773	773	0	114	773	773	773	773	773	773	773	773	773	362	773	773	773	773	770	773	773	773	773	689
4	I	1,045	1,045	0	0	0	1,045	1,045	0	628	1,045	884	1,045	1,045	0	481	820	1,045	1,045	0	494	1,045	886	1,045	665
	II	627	627	0	0	0	627	627	627	627	627	627	627	627	355	627	627	627	627	627	627	627	627	627	529
	III	731	731	0	0	0	731	731	731	731	731	731	731	731	0	731	731	731	731	731	731	731	731	731	598
	IV	418	418	0	405	418	418	418	418	418	418	418	418	418	418	418	418	418	418	418	418	418	418	418	398
	Average	705	705	0	101	104	705	705	444	601	705	665	705	705	193	564	649	705	705	444	568	705	665	705	548
5	I	1,417	676	0	0	0	0	829	0	0	1,417	0	994	708	0	0	0	0	933	0	0	594	0	190	288
	II	850	850	0	0	0	600	850	850	850	850	850	850	850	0	850	850	850	850	850	850	850	850	850	684
	III	992	992	0	0	0	0	992	0	510	992	813	992	992	0	710	897	992	992	392	717	992	940	992	632
	IV	567	567	0	509	567	567	567	567	567	567	567	567	567	435	567	567	567	567	567	567	567	567	567	532
	Average	956	771	0	127	142	292	809	354	482	956	557	851	779	109	532	578	602	835	452	533	751	589	650	534
6	I	1,077	0	0	0	0	0	0	0	0	1,077	0	0	0	0	0	0	0	0	0	0	0	0	0	49
	II	646	646	0	0	0	0	474	449	576	646	646	646	646	0	628	646	646	646	467	595	646	646	646	468
	III	754	582	0	0	0	0	0	0	0	754	0	276	637	0	0	226	754	667	0	0	576	0	490	225
	IV	431	431	0	253	365	431	431	431	431	431	431	431	431	0	431	431	431	431	431	431	431	431	431	381
	Average	727	415	0	63	91	108	226	220	252	727	269	338	428	0	265	326	458	436	224	256	413	269	392	281
7	I	945	945	0	945	945	945	945	0	945	945	945	945	945	0	945	945	945	945	938	945	945	945	945	815
	II	567	567	0	567	567	567	567	332	567	567	567	567	567	567	567	567	567	567	567	567	567	567	567	530
	III	661	661	0	661	661	661	661	0	661	661	661	661	661	313	661	661	661	661	661	661	661	661	661	585
	IV	378	378	0	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	361
	Average	638	638	0	638	638	638	638	178	638	638	638	638	638	314	638	638	638	638	636	638	638	638	638	573
8	I	977	977	0	0	0	551	977	0	0	977	977	977	977	0	702	901	977	977	360	708	977	945	977	633
	II	586	586	0	586	586	586	586	446	586	586	586	586	586	488	586	586	586	586	586	586	586	586	586	549
	III	684	684	0	640	684	684	684	0	183	684	684	684	684	0	684	684	684	684	684	684	684	684	684	566
	IV	391	391	0	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	373
	Average	659	659	0	404	415	553	659	209	290	659	659	659	659	220	591	640	659	659	505	592	659	651	659	530
9	I	1,465	706	0	0	0	0	773	0	0	1,465	0	773	724	0	0	0	0	781	0	0	482	0	473	281
	II	879	879	0	0	197	736	879	879	879	879	879	879	879	0	879	879	879	879	879	879	879	879	879	722
	III	1,026	1,026	0	0	0	0	1,026	178	683	1,026	933	1,026	1,026	0	290	809	1,026	1,026	215	705	1,026	1,026	1,026	640
	IV	586	586	0	586	586	586	586	586	586	586	586	586	586	0	586	586	586	586	586	586	586	586	586	533
	Average	989	799	0	147	196	330	816	411	537	989	600	816	804	0	439	569	623	818	420	542	743	623	741	544
10	I	1,425	0	0	0	0	0	0	0	0	1,425	0	0	0	0	0	0	0	0	0	0	0	0	0	65
	II	855	855	0	0	0	291	855	702	845	855	855	671	855	0	855	855	855	855	591	802	855	849	855	643
	III	997	858	0	0	0	0	487	0	0	997	368	0	809	0	0	482	997	986	0	0	859	0	704	343
	IV	570	570	0	423	547	570	570	570	570	570	570	570	570	0	570	570	570	570	570	570	570	570	570	510
	Average	962	571	0	106	137	215	478	318	354	962	448	310	558	0	356	477	606	603	290	343	571	355	532	390

Table C.4. Nodal Flow Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	Maximum Demand	State*																						Average
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
11	I	777	777	0	777	777	777	777	777	777	777	777	777	777	0	777	777	777	777	777	777	777	777	777	706
	II	466	466	375	466	466	466	466	466	466	466	466	466	466	0	466	466	466	466	466	466	466	466	466	441
	III	544	544	0	544	544	544	544	544	544	544	544	544	544	0	544	544	544	544	544	544	544	544	544	494
	IV	311	311	311	311	311	311	311	311	311	311	311	311	311	0	311	311	311	311	311	311	311	311	311	297
	Average	524	524	171	524	524	524	524	524	524	524	524	524	524	0	524	524	524	524	524	524	524	524	524	484
12	I	950	950	0	0	0	0	950	653	820	950	950	950	950	0	0	950	950	950	716	858	950	950	950	657
	II	570	570	0	570	570	570	570	570	570	570	570	570	570	0	477	570	570	570	570	570	570	570	570	514
	III	665	665	0	525	642	665	665	665	665	665	665	665	665	0	0	665	665	665	665	665	665	665	665	567
	IV	380	380	0	380	380	380	380	380	380	380	380	380	380	0	380	380	380	380	380	380	380	380	380	345
	Average	641	641	0	369	398	404	641	567	609	641	641	641	641	0	214	641	641	641	583	618	641	641	641	521
13	I	1,453	0	0	0	0	0	0	0	0	1,453	0	0	0	0	0	0	1,021	0	0	0	0	889	482	175
	II	872	872	0	366	660	834	872	872	872	872	872	872	872	0	577	872	872	872	720	872	872	872	872	738
	III	1,017	1,016	0	0	0	0	990	407	640	1,017	804	945	1,012	0	0	0	1,017	960	0	0	941	1,017	1,017	536
	IV	581	581	0	581	581	581	581	581	581	581	581	581	581	0	581	581	581	581	581	581	581	581	458	523
	Average	981	617	0	237	310	354	611	465	523	981	564	599	616	0	290	363	873	603	325	363	599	840	707	493
14	I	969	0	0	0	0	0	0	0	0	969	0	0	0	0	0	0	0	0	0	0	0	0	0	44
	II	581	581	0	0	0	0	561	303	438	534	581	273	581	0	474	552	581	422	0	287	581	227	581	344
	III	678	365	0	0	0	0	0	0	0	678	0	0	315	0	0	0	678	0	0	0	378	0	0	110
	IV	388	388	0	157	281	351	388	388	388	388	388	388	388	0	388	388	388	388	350	388	388	388	388	334
	Average	654	334	0	39	70	88	237	173	206	642	242	165	321	0	215	235	412	202	87	169	337	154	242	208
15	I	935	935	0	0	579	855	935	935	935	935	935	935	935	0	935	935	935	935	0	935	935	935	935	745
	II	561	561	0	561	561	561	561	561	561	561	561	561	561	0	561	561	561	561	248	561	561	561	561	496
	III	655	655	0	655	655	655	655	655	655	655	655	655	655	0	655	655	655	655	0	655	655	655	655	565
	IV	374	374	323	374	374	374	374	374	374	374	374	374	374	0	374	374	374	374	374	374	374	374	374	355
	Average	631	631	81	397	542	611	631	631	631	631	631	631	631	0	631	631	631	631	156	631	631	631	631	540
16	I	750	618	0	0	0	0	526	0	0	750	121	376	602	0	0	0	750	445	0	0	743	750	750	292
	II	450	450	0	449	450	450	450	450	450	450	450	450	450	0	450	450	450	450	121	441	450	450	450	394
	III	525	525	0	0	182	381	525	499	525	525	525	525	525	0	479	525	525	525	0	0	525	525	525	380
	IV	300	300	0	300	300	300	300	300	300	300	300	300	300	0	300	300	300	300	300	300	300	300	300	273
	Average	506	473	0	187	233	283	450	312	319	506	349	413	469	0	307	319	506	430	105	185	504	506	506	335
17	I	1,050	0	0	0	0	0	0	0	0	1,050	0	0	0	0	0	0	0	0	0	0	0	0	677	79
	II	630	630	0	0	425	588	630	630	630	630	630	630	630	0	630	630	630	630	0	530	630	264	630	483
	III	735	735	0	0	0	0	653	168	423	735	569	449	733	0	345	539	735	544	0	0	735	0	735	368
	IV	420	420	0	420	420	420	420	420	420	420	420	420	420	0	420	420	420	420	420	420	420	420	420	382
	Average	709	446	0	105	211	252	426	304	368	709	405	375	446	0	349	397	446	398	105	238	446	171	615	328
Sum	I	17,122	9,517	0	2,466	4,190	6,061	9,644	4,254	5,994	17,122	7,477	9,659	9,551	205	5,728	7,216	9,288	9,676	4,671	6,606	9,336	8,965	10,088	7,169
	II	10,273	10,273	375	4,011	5,615	8,008	10,081	9,272	10,050	10,226	10,273	9,781	10,273	2,542	9,761	10,244	10,273	10,114	7,825	9,766	10,273	9,547	10,273	8,584
	III	11,986	11,360	0	3,546	4,689	5,642	9,933	5,167	7,543	11,986	9,274	9,474	11,311	1,138	6,420	8,740	11,986	10,961	5,214	6,683	11,293	8,769	10,750	7,813
	IV	6,849	6,849	634	6,222	6,653	6,813	6,849	6,849	6,849	6,849	6,849	6,849	6,849	2,377	6,849	6,849	6,849	6,849	6,811	6,849	6,849	6,849	6,725	6,317
	Average	11,558	9,500	252	4,061	5,287	6,631	9,127	6,385	7,609	11,546	8,468	8,941	9,496	1,566	7,189	8,262	9,599	9,400	6,130	7,476	9,438	8,533	9,459	7,471
Volume Reliability	I		0.556	0.000	0.144	0.245	0.354	0.563	0.248	0.350	1.000	0.437	0.564	0.558	0.012	0.335	0.421	0.542	0.565	0.273	0.386	0.545	0.524	0.589	0.419
	II		1.000	0.037	0.390	0.547	0.779	0.981	0.902	0.978	0.995	1.000	0.952	1.000	0.247	0.950	0.997	1.000	0.984	0.762	0.951	1.000	0.929	1.000	0.836
	III		0.948	0.000	0.296	0.391	0.471	0.829	0.431	0.629	1.000	0.774	0.790	0.944	0.095	0.536	0.729	1.000	0.914	0.435	0.558	0.942	0.732	0.897	0.652
	IV		1.000	0.093	0.909	0.971	0.995	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.347	1.000	1.000	1.000	1.000	0.994	1.000	1.000	1.000	0.982	0.922
	Average		0.876	0.032	0.435	0.538	0.650	0.843	0.646	0.739	0.999	0.803	0.827	0.875	0.175	0.705	0.787	0.886	0.866	0.616	0.724	0.872	0.796	0.867	0.707

*) Refer to Table 4.11

Table C.5. Nodal Flow Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	Average Demand	State*																						Average
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	600	600	0	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	573
	II	360	360	0	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	344
	III	420	420	0	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	401
	IV	240	240	0	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	229
	Average	405	405	0	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	405	387
3	I	1,000	1,000	0	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	864
	II	600	600	0	572	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	571
	III	700	700	0	0	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	636
	IV	400	400	0	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	382
	Average	675	675	0	243	675	675	675	675	675	675	675	675	675	425	675	675	675	675	675	675	675	675	675	613
4	I	900	900	0	0	0	900	900	900	900	900	900	900	900	0	900	900	900	900	900	900	900	900	900	736
	II	540	540	0	459	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	512
	III	630	630	0	0	339	630	630	630	630	630	630	630	630	492	630	630	630	630	630	630	630	630	630	553
	IV	360	360	0	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	344
	Average	608	608	0	205	310	608	608	608	608	608	608	608	608	348	608	608	608	608	608	608	608	608	608	536
5	I	1,200	1,200	0	0	0	0	1,200	0	0	849	1,200	1,200	1,200	0	633	1,010	1,200	1,200	0	655	1,200	1,076	1,200	683
	II	720	720	0	571	720	720	720	720	720	720	720	720	720	426	720	720	720	720	720	720	720	720	720	667
	III	840	840	0	0	298	743	840	840	840	840	840	840	840	0	840	840	840	840	840	840	840	840	840	696
	IV	480	480	0	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	458
	Average	810	810	0	263	375	486	810	510	510	722	810	810	810	226	668	762	810	810	510	674	810	779	810	626
6	I	900	669	0	0	0	0	0	0	0	0	816	0	762	0	0	0	522	809	0	0	660	0	503	215
	II	540	540	0	199	463	540	540	540	540	540	540	540	540	0	540	540	540	540	540	540	540	540	540	472
	III	630	630	0	0	0	289	558	540	630	630	630	630	630	0	630	630	630	630	551	630	630	630	630	489
	IV	360	360	0	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	344
	Average	608	550	0	140	206	297	364	360	383	383	586	383	573	90	383	383	513	585	363	383	548	383	508	380
7	I	800	800	0	800	800	800	800	0	800	800	800	800	800	0	800	800	800	800	800	800	800	800	800	691
	II	480	480	0	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	458
	III	560	560	0	560	560	560	560	439	560	560	560	560	560	560	560	560	560	560	560	560	560	560	560	529
	IV	320	320	0	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	305
	Average	540	540	0	540	540	540	540	310	540	540	540	540	540	340	540	540	540	540	540	540	540	540	540	496
8	I	800	800	0	705	800	800	800	0	0	800	800	800	800	0	800	800	800	800	800	800	800	800	800	650
	II	480	480	0	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	458
	III	560	560	0	560	560	560	560	516	560	560	560	560	560	551	560	560	560	560	560	560	560	560	560	532
	IV	320	320	0	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	305
	Average	540	540	0	516	540	540	540	329	340	540	540	540	540	338	540	540	540	540	540	540	540	540	540	486
9	I	1,200	1,200	0	0	0	0	1,200	0	423	966	0	1,200	1,200	0	0	740	1,198	1,200	0	495	1,200	1,199	1,200	610
	II	720	720	0	673	720	720	720	720	720	720	720	720	720	0	720	720	720	720	720	720	720	720	720	652
	III	840	840	0	0	496	833	840	840	840	840	840	840	840	0	840	840	840	840	840	840	840	840	840	709
	IV	480	480	0	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	458
	Average	810	810	0	288	424	508	810	510	616	751	510	810	810	120	510	695	809	810	510	634	810	810	810	608
10	I	1,200	987	0	0	0	0	0	0	0	0	1,121	0	900	0	0	0	845	1,200	0	0	990	0	700	306
	II	720	720	0	422	697	720	720	720	720	720	720	720	720	0	720	720	720	720	720	720	720	720	720	640
	III	840	840	0	0	0	537	840	808	840	840	840	783	840	0	840	840	840	840	719	840	840	840	840	664
	IV	480	480	0	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	458
	Average	810	757	0	226	294	434	510	502	510	510	790	496	735	120	510	510	721	810	480	510	757	510	685	517

Table C.5. Nodal Flow Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	Average Demand	State*																						Average
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
11	I	600	600	0	600	600	600	600	600	600	600	600	600	600	0	600	600	600	600	600	600	600	600	600	545
	II	360	360	360	360	360	360	360	360	360	360	360	360	360	0	360	360	360	360	360	360	360	360	360	344
	III	420	420	402	420	420	420	420	420	420	420	420	420	420	0	420	420	420	420	420	420	420	420	420	400
	IV	240	240	240	240	240	240	240	240	240	240	240	240	240	74	240	240	240	240	240	240	240	240	240	232
	Average	405	405	251	405	405	405	405	405	405	405	405	405	405	18	405	405	405	405	405	405	405	405	405	380
12	I	800	800	0	529	752	800	800	800	800	800	800	800	800	0	0	800	800	800	800	800	800	800	800	676
	II	480	480	0	480	480	480	480	480	480	480	480	480	480	0	480	480	480	480	480	480	480	480	480	436
	III	560	560	0	560	560	560	560	560	560	560	560	560	560	0	552	560	560	560	560	560	560	560	560	509
	IV	320	320	320	320	320	320	320	320	320	320	320	320	320	101	320	320	320	320	320	320	320	320	320	310
	Average	540	540	80	472	528	540	540	540	540	540	540	540	540	25	338	540	540	540	540	540	540	540	540	483
13	I	1,200	1,200	0	0	0	0	1,200	0	662	939	781	1,165	1,200	0	0	0	1,200	1,192	0	0	1,161	1,200	1,200	595
	II	720	720	0	720	720	720	720	720	720	720	720	720	720	0	720	720	720	720	720	720	720	720	720	655
	III	840	840	0	555	766	840	840	840	840	840	840	840	840	0	705	840	840	840	809	840	840	840	840	740
	IV	480	480	0	480	480	480	480	480	480	480	480	480	480	0	480	480	480	480	480	480	480	480	400	433
	Average	810	810	0	439	492	510	810	510	675	745	705	801	810	0	476	510	810	808	502	510	800	810	790	606
14	I	800	365	0	0	0	0	0	0	0	0	443	0	260	0	0	0	218	0	0	0	389	0	0	76
	II	480	480	0	0	354	480	480	480	480	480	480	480	480	0	480	480	480	480	476	480	480	480	480	409
	III	560	560	0	0	0	50	560	405	504	560	560	385	560	0	531	560	560	495	0	398	560	349	560	371
	IV	320	320	0	320	320	320	320	320	320	320	320	320	320	239	320	320	320	320	320	320	320	320	320	302
	Average	540	431	0	80	169	213	340	301	326	340	451	296	405	60	333	340	394	324	199	299	437	287	340	289
15	I	800	800	0	800	800	800	800	800	800	800	800	800	800	0	800	800	800	800	0	800	800	800	800	691
	II	480	480	286	480	480	480	480	480	480	480	480	480	480	0	480	480	480	480	480	480	480	480	480	449
	III	560	560	0	560	560	560	560	560	560	560	560	560	560	0	560	560	560	560	390	560	560	560	560	501
	IV	320	320	320	320	320	320	320	320	320	320	320	320	320	225	320	320	320	320	320	320	320	320	320	316
	Average	540	540	152	540	540	540	540	540	540	540	540	540	540	56	540	540	540	540	297	540	540	540	540	489
16	I	600	600	0	0	0	306	600	526	600	600	600	600	600	0	490	600	600	600	0	0	600	600	600	415
	II	360	360	0	360	360	360	360	360	360	360	360	360	360	0	360	360	360	360	360	360	360	360	360	327
	III	420	420	0	420	420	420	420	420	420	420	420	420	420	0	420	420	420	420	252	420	420	420	420	374
	IV	240	240	177	240	240	240	240	240	240	240	240	240	240	140	240	240	240	240	240	240	240	240	240	233
	Average	405	405	44	255	255	331	405	386	405	405	405	405	405	35	378	405	405	405	213	255	405	405	405	337
17	I	900	900	0	0	0	0	734	0	171	571	862	264	879	0	0	509	900	526	0	0	900	0	900	369
	II	540	540	0	540	540	540	540	540	540	540	540	540	540	0	540	540	540	540	540	540	540	540	540	491
	III	630	630	0	306	535	630	630	630	630	630	630	630	630	0	630	630	630	630	249	622	630	404	630	526
	IV	360	360	0	360	360	360	360	360	360	360	360	360	360	173	360	360	360	360	360	360	360	360	360	335
	Average	608	608	0	302	359	383	566	383	425	525	598	448	602	43	383	510	608	514	287	380	608	326	608	430
Sum	I	14,300	13,420	0	4,034	5,352	6,606	11,234	5,226	7,355	10,224	12,123	10,729	13,301	600	6,623	9,159	12,982	13,027	5,500	7,450	13,399	10,375	12,602	8,696
	II	8,580	8,580	646	7,157	8,354	8,580	8,580	8,580	8,580	8,580	8,580	8,580	8,580	2,886	8,580	8,580	8,580	8,580	8,576	8,580	8,580	8,580	8,580	7,885
	III	10,010	10,010	402	4,361	6,634	8,751	9,938	9,569	9,954	10,010	10,010	9,777	10,010	2,723	9,838	10,010	10,010	9,945	8,500	9,839	10,010	9,573	10,010	8,631
	IV	5,720	5,720	1,057	5,720	5,720	5,720	5,720	5,720	5,720	5,720	5,720	5,720	5,720	4,391	5,720	5,720	5,720	5,720	5,720	5,720	5,720	5,720	5,640	5,444
	Average	9,653	9,433	527	5,318	6,515	7,414	8,868	7,274	7,902	8,633	9,108	8,701	9,403	2,650	7,690	8,367	9,323	9,318	7,074	7,897	9,427	8,562	9,208	7,664
Volume Reliability	I		0.938	0.000	0.282	0.374	0.462	0.786	0.365	0.514	0.715	0.848	0.750	0.930	0.042	0.463	0.640	0.908	0.911	0.385	0.521	0.937	0.726	0.881	0.608
	II		1.000	0.075	0.834	0.974	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.336	1.000	1.000	1.000	1.000	0.999	1.000	1.000	1.000	1.000	0.919
	III		1.000	0.040	0.436	0.663	0.874	0.993	0.956	0.994	1.000	1.000	0.977	1.000	0.272	0.983	1.000	1.000	0.993	0.849	0.983	1.000	0.956	1.000	0.862
	IV		1.000	0.185	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.768	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.986	0.952
	Average		0.985	0.075	0.638	0.753	0.834	0.945	0.830	0.877	0.929	0.962	0.932	0.983	0.354	0.861	0.910	0.977	0.976	0.808	0.876	0.984	0.920	0.967	0.835

*) Refer to Table 4.11

Table D.1. Hydraulic Reliability Under Average Demand During Various Demand Patterns

Node	Demand Pattern	State*																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
2	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3	I	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.089	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.522	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
4	I	1.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.868	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.500	0.717	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	I	1.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.711	1.000	1.000	1.000	0.000	0.533	0.845	1.000	1.000	0.000	0.551	1.000	0.900	1.000
	II	1.000	0.000	0.959	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.800	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.768	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.490	0.692	0.750	1.000	0.750	0.750	0.928	1.000	1.000	1.000	0.450	0.883	0.961	1.000	1.000	0.750	0.888	1.000	0.975	1.000
6	I	0.748	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.910	0.000	0.851	0.000	0.000	0.000	0.587	0.902	0.000	0.000	0.738	0.000	0.564
	II	1.000	0.000	0.653	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.205	0.821	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.937	0.000	0.413	0.551	0.705	0.750	0.750	0.750	0.750	0.977	0.750	0.963	0.250	0.750	0.750	0.897	0.976	0.750	0.750	0.934	0.750	0.891
7	I	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	I	1.000	0.000	0.885	1.000	1.000	1.000	0.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.971	1.000	1.000	1.000	0.750	0.750	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	I	1.000	0.000	0.000	0.000	0.000	1.000	0.000	0.363	0.810	0.000	1.000	1.000	0.000	0.000	0.621	1.000	1.000	0.000	0.420	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.173	0.901	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.543	0.725	0.750	1.000	0.750	0.841	0.952	0.750	1.000	1.000	0.250	0.750	0.905	1.000	1.000	0.750	0.855	1.000	1.000	1.000

Table D.1. Hydraulic Reliability Under Average Demand During Various Demand Patterns

Node	Demand Pattern	State*																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
10	I	0.826	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.938	0.000	0.754	0.000	0.000	0.000	0.710	1.000	0.000	0.000	0.828	0.000	0.588
	II	1.000	0.000	0.796	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.494	0.934	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.956	0.000	0.449	0.623	0.733	0.750	0.750	0.750	0.750	0.985	0.750	0.938	0.250	0.750	0.750	0.927	1.000	0.750	0.750	0.957	0.750	0.897
11	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.869	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.217	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	I	1.000	0.000	0.666	0.944	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.873	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.250	0.917	0.986	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.218	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
13	I	1.000	0.000	0.000	0.000	0.000	1.000	0.000	0.557	0.786	0.656	0.975	1.000	0.000	0.000	0.000	1.000	0.996	0.000	0.000	0.971	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.949	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.494	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.675	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.123	0.737	0.750	0.750	1.000	0.750	0.889	0.947	0.914	0.994	1.000	0.169	0.750	0.750	1.000	0.999	0.750	0.750	0.993	1.000	1.000
14	I	0.465	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.559	0.000	0.335	0.000	0.000	0.000	0.283	0.000	0.000	0.000	0.492	0.000	0.000
	II	1.000	0.000	0.508	0.913	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	0.687	1.000	0.994	1.000	1.000	1.000	0.967	1.000	0.000	1.000	1.000	1.000	1.000	0.662	0.984	1.000	0.923	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.866	0.000	0.377	0.478	0.672	0.750	0.748	0.750	0.750	0.890	0.742	0.834	0.250	0.750	0.750	0.821	0.750	0.665	0.746	0.873	0.731	0.750
15	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000
	II	1.000	0.805	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.974	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.451	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.250	1.000	1.000	1.000	1.000	0.743	1.000	1.000	1.000	1.000
16	I	1.000	0.000	0.000	0.000	0.516	1.000	0.881	1.000	1.000	1.000	1.000	1.000	0.000	0.822	1.000	1.000	1.000	0.000	0.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.908	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.250	0.750	0.750	0.879	1.000	0.970	1.000	1.000	1.000	1.000	1.000	0.250	0.956	1.000	1.000	1.000	0.727	0.750	1.000	1.000	1.000
17	I	1.000	0.000	0.000	0.000	0.000	0.820	0.000	0.210	0.639	0.962	0.303	0.980	0.000	0.000	0.571	1.000	0.590	0.000	0.000	1.000	0.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.837	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.787	1.000	1.000	0.936	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.944	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.709	0.750	0.750	0.955	0.750	0.802	0.910	0.991	0.826	0.995	0.236	0.750	0.893	1.000	0.897	0.697	0.750	1.000	0.734	1.000

*) Refer to Table 4.11

Table D.2. Hydraulic Reliability Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	State*																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
2	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.316	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.829	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3	I	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.250	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
4	I	1.000	0.000	0.000	0.000	1.000	1.000	0.118	0.621	0.860	1.000	1.000	1.000	0.000	0.486	0.800	1.000	1.000	0.000	0.500	1.000	0.863	1.000
	II	1.000	0.000	0.000	0.763	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.951	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.250	0.441	1.000	1.000	0.780	0.905	0.965	1.000	1.000	1.000	0.488	0.871	0.950	1.000	1.000	0.750	0.875	1.000	0.966	1.000
5	I	0.504	0.000	0.000	0.000	0.000	0.605	0.000	0.000	0.000	0.864	0.718	0.523	0.000	0.000	0.000	0.000	0.677	0.000	0.000	0.449	0.000	0.205
	II	1.000	0.000	0.000	0.647	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	0.000	1.000	0.877	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.876	0.000	0.250	0.412	0.500	0.901	0.719	0.750	0.750	0.966	0.930	0.881	0.250	0.750	0.750	0.750	0.919	0.750	0.750	0.862	0.750	0.801
6	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	1.000	0.000	0.000	0.000	0.709	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	0.000	0.412	0.316	0.716	0.950	1.000	1.000	1.000	0.000	0.845	1.000	1.000	1.000	0.390	0.764	1.000	0.932	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.750	0.000	0.250	0.250	0.427	0.603	0.579	0.679	0.737	0.750	0.750	0.750	0.250	0.711	0.750	0.750	0.750	0.597	0.691	0.750	0.733	0.750
7	I	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	0.964	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	1.000	1.000	1.000	1.000	0.491	1.000	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	I	1.000	0.000	0.000	0.000	0.585	1.000	0.000	0.000	1.000	1.000	1.000	1.000	0.000	0.736	0.935	1.000	1.000	0.400	0.743	1.000	0.980	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	0.310	1.000	1.000	1.000	1.000	1.000	0.496	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.750	0.750	0.896	1.000	0.577	0.750	1.000	1.000	1.000	1.000	0.624	0.934	0.984	1.000	1.000	0.850	0.936	1.000	0.995	1.000
9	I	0.508	0.000	0.000	0.000	0.000	0.550	0.000	0.000	0.000	0.000	0.550	0.518	0.000	0.000	0.000	0.000	0.555	0.000	0.000	0.363	0.000	0.358
	II	1.000	0.000	0.000	0.797	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	0.434	1.000	0.982	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.988	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.877	0.000	0.250	0.449	0.608	0.887	0.745	0.750	0.750	0.750	0.887	0.879	0.250	0.750	0.750	0.750	0.889	0.747	0.750	0.841	0.750	0.839

Table D.2. Hydraulic Reliability Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	State*																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
10	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	1.000	0.000	0.000	0.253	0.838	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	0.000	1.000	0.537	0.831	1.000	1.000	0.456	1.000	0.000	0.926	1.000	1.000	1.000	0.167	0.750	1.000	0.839	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.750	0.000	0.250	0.313	0.459	0.750	0.634	0.708	0.750	0.750	0.614	0.750	0.250	0.732	0.750	0.750	0.750	0.542	0.687	0.750	0.710	0.750
11	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.431	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.608	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	I	1.000	0.000	0.000	0.000	0.100	1.000	0.706	0.879	1.000	0.946	1.000	1.000	0.000	0.000	1.000	1.000	1.000	0.769	0.918	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.506	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.250	0.750	0.750	0.775	1.000	0.926	0.970	1.000	0.986	1.000	1.000	0.000	0.626	1.000	1.000	1.000	0.942	0.979	1.000	1.000	1.000
13	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.721	0.000	0.000	0.000	0.000	0.631	0.369
	II	1.000	0.000	0.872	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.467	0.820	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.195	0.939	1.000	1.000	0.603	0.898	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.750	0.000	0.468	0.617	0.705	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.000	0.549	0.735	0.930	0.750	0.651	0.724	0.750	0.908	0.842
14	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	1.000	0.000	0.000	0.000	0.550	1.000	0.925	1.000	1.000	1.000	0.897	1.000	0.000	1.000	1.000	1.000	1.000	0.535	0.910	1.000	0.858	1.000
	III	1.000	0.000	0.000	0.000	0.000	0.871	0.000	0.527	0.804	1.000	0.000	1.000	0.000	0.639	0.849	1.000	0.471	0.000	0.000	1.000	0.000	0.939
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.422	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.750	0.000	0.250	0.250	0.387	0.718	0.481	0.632	0.701	0.750	0.474	0.750	0.105	0.660	0.712	0.750	0.618	0.384	0.477	0.750	0.464	0.735
15	I	1.000	0.000	0.000	0.639	0.927	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.883	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.250	0.750	0.910	0.982	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.471	1.000	1.000	1.000	1.000
16	I	0.839	0.000	0.000	0.000	0.000	0.718	0.000	0.000	0.224	0.492	0.525	0.819	0.000	0.000	0.000	1.000	0.613	0.000	0.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.810	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.762	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	0.731	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.960	0.000	0.690	0.750	0.750	0.930	0.750	0.750	0.806	0.873	0.881	0.955	0.000	0.750	0.750	1.000	0.903	0.452	0.683	1.000	1.000	1.000
17	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.663
	II	1.000	0.000	0.744	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.672	1.000	1.000	0.873	1.000
	III	1.000	0.000	0.000	0.000	0.694	1.000	0.993	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	0.514	1.000	0.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.750	0.000	0.436	0.500	0.674	0.750	0.748	0.750	0.750	0.750	0.750	0.750	0.000	0.750	0.750	0.750	0.750	0.418	0.628	0.750	0.468	0.916

*) Refer to Table 4.11

Table D.3. Hydraulic Reliability Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	State*																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
2	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3	I	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
4	I	1.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.179	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.750	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.795	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	I	1.000	0.000	0.000	0.000	0.542	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.750	0.750	0.886	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6	I	1.000	0.000	0.000	0.000	0.000	0.603	0.600	0.858	1.000	1.000	1.000	1.000	0.000	0.957	1.000	1.000	1.000	0.608	0.898	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.888	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.494	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.722	0.750	0.750	0.901	0.900	0.964	1.000	1.000	1.000	1.000	0.623	0.989	1.000	1.000	1.000	0.902	0.974	1.000	1.000	1.000
7	I	1.000	0.000	1.000	1.000	1.000	1.000	0.427	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	1.000	1.000	1.000	1.000	0.857	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	I	1.000	0.000	1.000	1.000	1.000	1.000	0.651	1.000	1.000	1.000	1.000	1.000	0.752	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	1.000	1.000	1.000	1.000	0.913	1.000	1.000	1.000	1.000	1.000	0.938	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	I	1.000	0.000	0.000	0.000	0.706	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.290	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.750	0.750	0.926	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.572	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table D.3. Hydraulic Reliability Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	State*																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
10	I	1.000	0.000	0.000	0.000	0.000	1.000	0.739	0.955	1.000	1.000	0.639	1.000	0.000	1.000	1.000	1.000	1.000	0.506	0.891	1.000	0.932	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.200	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.749	0.750	0.750	1.000	0.935	0.989	1.000	1.000	0.910	1.000	0.550	1.000	1.000	1.000	1.000	0.876	0.973	1.000	0.983	1.000
11	I	1.000	0.717	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.929	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.250	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.727	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.488	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.622	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.250	0.932	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
13	I	1.000	0.000	0.000	0.693	0.956	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.559	1.000	1.000	1.000	0.772	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.250	0.750	0.923	0.989	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.250	0.890	1.000	1.000	1.000	0.943	1.000	1.000	1.000	1.000
14	I	1.000	0.000	0.000	0.000	0.000	0.964	0.379	0.709	0.915	1.000	0.126	1.000	0.000	0.782	0.957	1.000	0.688	0.000	0.326	1.000	0.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.352	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.785	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.696	0.750	0.750	0.991	0.845	0.927	0.979	1.000	0.782	1.000	0.338	0.946	0.989	1.000	0.922	0.750	0.831	1.000	0.750	1.000
15	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000
	II	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.250	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000
16	I	1.000	0.000	0.902	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	0.899	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.250	0.976	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.250	1.000	1.000	1.000	1.000	0.750	0.975	1.000	1.000	1.000
17	I	1.000	0.000	0.000	0.422	0.843	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	0.725	1.000	0.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.250	0.750	0.855	0.961	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.250	1.000	1.000	1.000	1.000	0.750	0.931	1.000	0.750	1.000

*) Refer to Table 4.11

Table D.4. Hydraulic Reliability Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
2	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.276	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.819	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3	I	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.992	1.000	1.000	1.000	1.000
	II	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.379	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.250	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.595	1.000	1.000	1.000	1.000	0.998	1.000	1.000	1.000	1.000
4	I	1.000	0.000	0.000	0.000	1.000	1.000	0.000	0.602	0.846	1.000	1.000	1.000	0.000	0.460	0.785	1.000	1.000	0.000	0.473	1.000	0.849	1.000
	II	1.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.566	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	0.970	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.242	0.250	1.000	1.000	0.750	0.900	0.962	1.000	1.000	1.000	0.391	0.865	0.946	1.000	1.000	0.750	0.868	1.000	0.962	1.000
5	I	0.477	0.000	0.000	0.000	0.000	0.585	0.000	0.000	0.000	0.850	0.701	0.500	0.000	0.000	0.000	0.000	0.659	0.000	0.000	0.420	0.000	0.134
	II	1.000	0.000	0.000	0.000	0.706	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	0.000	1.000	0.000	0.514	0.820	1.000	1.000	1.000	0.000	0.716	0.904	1.000	1.000	0.395	0.722	1.000	0.948	1.000
	IV	1.000	0.000	0.898	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.767	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.869	0.000	0.224	0.250	0.426	0.896	0.500	0.628	0.705	0.962	0.925	0.875	0.192	0.679	0.726	0.750	0.915	0.599	0.681	0.855	0.737	0.784
6	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	1.000	0.000	0.000	0.000	0.000	0.733	0.696	0.891	1.000	1.000	1.000	1.000	0.000	0.973	1.000	1.000	1.000	0.722	0.921	1.000	1.000	1.000
	III	0.772	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.892	0.366	0.845	0.000	0.000	0.300	0.666	0.884	0.000	0.000	0.764	0.000	0.650
	IV	1.000	0.000	0.587	0.849	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.693	0.000	0.147	0.212	0.250	0.433	0.424	0.473	0.500	0.723	0.592	0.711	0.000	0.493	0.575	0.667	0.721	0.431	0.480	0.691	0.500	0.662
7	I	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.993	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	0.587	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	0.473	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	1.000	1.000	1.000	1.000	0.397	1.000	1.000	1.000	1.000	1.000	0.618	1.000	1.000	1.000	1.000	0.998	1.000	1.000	1.000	1.000
8	I	1.000	0.000	0.000	0.000	0.564	1.000	0.000	0.000	1.000	1.000	1.000	1.000	0.000	0.718	0.922	1.000	1.000	0.369	0.725	1.000	0.967	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	0.762	1.000	1.000	1.000	1.000	1.000	0.832	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.936	1.000	1.000	1.000	0.000	0.268	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.734	0.750	0.891	1.000	0.440	0.567	1.000	1.000	1.000	1.000	0.458	0.930	0.980	1.000	1.000	0.842	0.931	1.000	0.992	1.000
9	I	0.482	0.000	0.000	0.000	0.000	0.527	0.000	0.000	0.000	0.000	0.527	0.494	0.000	0.000	0.000	0.000	0.533	0.000	0.000	0.329	0.000	0.322
	II	1.000	0.000	0.000	0.224	0.837	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	0.000	1.000	0.173	0.666	0.910	0.338	1.000	1.000	0.000	0.283	0.789	1.000	1.000	0.210	0.687	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.870	0.000	0.250	0.306	0.459	0.882	0.543	0.667	0.727	0.584	0.882	0.873	0.000	0.571	0.697	0.750	0.883	0.552	0.672	0.832	0.750	0.831

Table D.4. Hydraulic Reliability Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
10	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	1.000	0.000	0.000	0.000	0.341	1.000	0.821	0.989	1.000	1.000	0.785	1.000	0.000	1.000	1.000	1.000	1.000	0.691	0.938	1.000	0.993	1.000
	III	0.860	0.000	0.000	0.000	0.000	0.488	0.000	0.000	0.369	0.941	0.000	0.811	0.000	0.000	0.484	0.784	0.989	0.000	0.000	0.861	0.000	0.706
	IV	1.000	0.000	0.742	0.959	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.715	0.000	0.185	0.240	0.335	0.622	0.455	0.497	0.592	0.735	0.446	0.703	0.000	0.500	0.621	0.696	0.747	0.423	0.485	0.715	0.498	0.676
11	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.805	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.451	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	I	1.000	0.000	0.000	0.000	0.000	1.000	0.687	0.864	1.000	0.932	1.000	1.000	0.000	0.000	1.000	1.000	1.000	0.754	0.903	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.837	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.790	0.965	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.697	0.741	0.750	1.000	0.922	0.966	1.000	0.983	1.000	1.000	0.000	0.459	1.000	1.000	1.000	0.938	0.976	1.000	1.000	1.000
13	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.703	0.000	0.000	0.000	0.000	0.612	0.332
	II	1.000	0.000	0.420	0.756	0.956	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.662	1.000	1.000	1.000	0.826	1.000	1.000	1.000	1.000
	III	0.999	0.000	0.000	0.000	0.000	0.973	0.400	0.629	0.790	0.677	0.928	0.995	0.000	0.000	0.000	1.000	0.943	0.000	0.000	0.925	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.750	0.000	0.355	0.439	0.489	0.743	0.600	0.657	0.697	0.669	0.732	0.749	0.000	0.415	0.500	0.926	0.736	0.456	0.500	0.731	0.903	0.833
14	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	1.000	0.000	0.000	0.000	0.000	0.964	0.522	0.754	0.919	1.000	0.469	1.000	0.000	0.816	0.949	1.000	0.725	0.000	0.494	1.000	0.390	1.000
	III	0.539	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.600	0.000	0.465	0.000	0.000	0.000	0.443	0.000	0.000	0.000	0.557	0.000	0.000
	IV	1.000	0.000	0.405	0.724	0.907	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.902	1.000	1.000	1.000	1.000
	Average	0.635	0.000	0.101	0.181	0.227	0.491	0.380	0.438	0.480	0.650	0.367	0.616	0.000	0.454	0.487	0.611	0.431	0.226	0.373	0.639	0.347	0.500
15	I	1.000	0.000	0.000	0.620	0.914	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.443	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000
	IV	1.000	0.864	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.216	0.750	0.905	0.979	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.361	1.000	1.000	1.000	1.000
16	I	0.825	0.000	0.000	0.000	0.000	0.701	0.000	0.000	0.161	0.467	0.502	0.802	0.000	0.000	0.000	1.000	0.593	0.000	0.000	0.991	1.000	1.000
	II	1.000	0.000	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.268	0.980	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.346	0.725	1.000	0.950	1.000	1.000	1.000	1.000	1.000	0.000	0.912	1.000	1.000	1.000	0.000	0.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.956	0.000	0.499	0.587	0.681	0.925	0.737	0.750	0.790	0.867	0.875	0.951	0.000	0.728	0.750	1.000	0.898	0.317	0.495	0.998	1.000	1.000
17	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.645
	II	1.000	0.000	0.000	0.675	0.933	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	0.841	1.000	0.420	1.000
	III	1.000	0.000	0.000	0.000	0.000	0.889	0.228	0.576	0.775	0.983	0.612	0.998	0.000	0.469	0.733	1.000	0.740	0.000	0.000	1.000	0.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.750	0.000	0.250	0.419	0.483	0.722	0.557	0.644	0.694	0.746	0.653	0.749	0.000	0.617	0.683	0.750	0.685	0.250	0.460	0.750	0.355	0.911

*) Refer to Table 4.11

Table D.5. Hydraulic Reliability Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
2	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3	I	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	0.953	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.488	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
4	I	1.000	0.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	0.850	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.539	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.781	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.462	0.635	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.695	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	I	1.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.707	1.000	1.000	1.000	0.000	0.527	0.841	1.000	1.000	0.000	0.546	1.000	0.897	1.000
	II	1.000	0.000	0.794	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.592	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.355	0.884	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.448	0.589	0.721	1.000	0.750	0.750	0.927	1.000	1.000	1.000	0.398	0.882	0.960	1.000	1.000	0.750	0.886	1.000	0.974	1.000
6	I	0.743	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.907	0.000	0.846	0.000	0.000	0.000	0.580	0.899	0.000	0.000	0.733	0.000	0.559
	II	1.000	0.000	0.369	0.858	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	0.458	0.885	0.858	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.875	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.936	0.000	0.342	0.464	0.615	0.721	0.714	0.750	0.750	0.977	0.750	0.962	0.250	0.750	0.750	0.895	0.975	0.719	0.750	0.933	0.750	0.890
7	I	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	0.784	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	1.000	1.000	1.000	1.000	0.696	1.000	1.000	1.000	1.000	1.000	0.750	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	I	1.000	0.000	0.881	1.000	1.000	1.000	0.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	0.921	1.000	1.000	1.000	1.000	1.000	0.984	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.970	1.000	1.000	1.000	0.730	0.750	1.000	1.000	1.000	1.000	0.746	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	I	1.000	0.000	0.000	0.000	0.000	1.000	0.000	0.352	0.805	0.000	1.000	1.000	0.000	0.000	0.616	0.998	1.000	0.000	0.412	1.000	0.999	1.000
	II	1.000	0.000	0.935	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.590	0.992	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.484	0.647	0.748	1.000	0.750	0.838	0.951	0.750	1.000	1.000	0.250	0.750	0.904	0.999	1.000	0.750	0.853	1.000	1.000	1.000

Table D.5. Hydraulic Reliability Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
10	I	0.822	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.934	0.000	0.750	0.000	0.000	0.000	0.704	1.000	0.000	0.000	0.825	0.000	0.583
	II	1.000	0.000	0.587	0.967	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	0.639	1.000	0.962	1.000	1.000	1.000	0.932	1.000	0.000	1.000	1.000	1.000	1.000	0.856	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.956	0.000	0.397	0.492	0.660	0.750	0.741	0.750	0.750	0.983	0.733	0.937	0.250	0.750	0.750	0.926	1.000	0.714	0.750	0.956	0.750	0.896
11	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.958	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.307	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.740	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.077	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	I	1.000	0.000	0.662	0.940	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.986	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.316	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.250	0.915	0.985	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.079	0.746	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
13	I	1.000	0.000	0.000	0.000	0.000	1.000	0.000	0.551	0.782	0.651	0.971	1.000	0.000	0.000	0.000	1.000	0.993	0.000	0.000	0.967	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.660	0.912	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.839	1.000	1.000	1.000	0.963	1.000	1.000	1.000	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.665	0.728	0.750	1.000	0.750	0.888	0.946	0.913	0.993	1.000	0.000	0.710	0.750	1.000	0.998	0.741	0.750	0.992	1.000	1.000
14	I	0.456	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.553	0.000	0.326	0.000	0.000	0.000	0.272	0.000	0.000	0.000	0.486	0.000	0.000
	II	1.000	0.000	0.000	0.738	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.991	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.000	0.000	0.089	1.000	0.724	0.900	1.000	1.000	0.687	1.000	0.000	0.948	1.000	1.000	0.883	0.000	0.710	1.000	0.623	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.747	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	0.864	0.000	0.250	0.434	0.522	0.750	0.681	0.725	0.750	0.888	0.672	0.831	0.187	0.737	0.750	0.818	0.721	0.498	0.677	0.871	0.656	0.750
15	I	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000
	II	1.000	0.597	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.696	1.000	1.000	1.000	1.000
	IV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.703	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.399	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.176	1.000	1.000	1.000	1.000	0.674	1.000	1.000	1.000	1.000
16	I	1.000	0.000	0.000	0.000	0.510	1.000	0.876	1.000	1.000	1.000	1.000	1.000	0.000	0.817	1.000	1.000	1.000	0.000	0.000	1.000	1.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.600	1.000	1.000	1.000	1.000
	IV	1.000	0.739	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.581	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.185	0.750	0.750	0.877	1.000	0.969	1.000	1.000	1.000	1.000	1.000	0.145	0.954	1.000	1.000	1.000	0.650	0.750	1.000	1.000	1.000
17	I	1.000	0.000	0.000	0.000	0.000	0.816	0.000	0.190	0.634	0.958	0.293	0.977	0.000	0.000	0.566	1.000	0.585	0.000	0.000	1.000	0.000	1.000
	II	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	III	1.000	0.000	0.486	0.850	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.395	0.987	1.000	0.642	1.000
	IV	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.480	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Average	1.000	0.000	0.621	0.712	0.750	0.954	0.750	0.797	0.909	0.990	0.823	0.994	0.120	0.750	0.891	1.000	0.896	0.599	0.747	1.000	0.660	1.000

*) Refer to Table 4.11

Table E.1. Overall System Hydraulic Reliability Under Average Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Hyd Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
3	I	0.547	0.547	0.547	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.948
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.549	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.965
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.556	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.970
4	I	0.547	0.547	0.547	0.547	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.935
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.547	0.558	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.961
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.556	0.556	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.966
5	I	0.547	0.547	0.547	0.547	0.547	0.568	0.547	0.547	0.562	0.561	0.562	0.567	0.547	0.554	0.565	0.560	0.564	0.547	0.554	0.562	0.566	0.567	0.847
	II	0.547	0.547	0.564	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.558	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.980
	III	0.547	0.547	0.547	0.556	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.945
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.556	0.556	0.556	0.568	0.555	0.558	0.567	0.561	0.562	0.567	0.553	0.558	0.568	0.560	0.564	0.559	0.558	0.562	0.568	0.567	0.939
6	I	0.409	0.409	0.409	0.409	0.409	0.409	0.409	0.409	0.409	0.422	0.409	0.426	0.409	0.409	0.409	0.417	0.425	0.409	0.409	0.420	0.409	0.421	0.549
	II	0.547	0.547	0.559	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.961
	III	0.547	0.547	0.547	0.550	0.557	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.935
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.857
7	I	0.547	0.547	0.565	0.559	0.559	0.568	0.547	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.956
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.565	0.559	0.559	0.568	0.555	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.977
8	I	0.547	0.547	0.563	0.559	0.559	0.568	0.547	0.547	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.937
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.564	0.559	0.559	0.568	0.555	0.558	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.972
9	I	0.547	0.547	0.547	0.547	0.547	0.568	0.547	0.553	0.564	0.547	0.562	0.567	0.547	0.547	0.560	0.560	0.564	0.547	0.552	0.562	0.569	0.567	0.828
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.550	0.558	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.950
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.557	0.556	0.556	0.568	0.555	0.560	0.568	0.557	0.562	0.567	0.550	0.556	0.567	0.560	0.564	0.559	0.558	0.562	0.569	0.567	0.933

Table E.1. Overall System Hydraulic Reliability Under Average Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Hyd Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.465	0.452	0.467	0.452	0.452	0.452	0.461	0.469	0.452	0.452	0.464	0.452	0.464	0.601
	II	0.547	0.547	0.561	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.964
	III	0.547	0.547	0.547	0.553	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.940
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.523	0.523	0.531	0.531	0.532	0.539	0.531	0.535	0.539	0.537	0.535	0.542	0.527	0.533	0.539	0.536	0.540	0.536	0.533	0.538	0.539	0.541	0.872
11	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.559	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.998
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.984
12	I	0.547	0.547	0.559	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.547	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.947
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.559	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.998
	Average	0.547	0.551	0.563	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.556	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.970
13	I	0.547	0.547	0.547	0.547	0.547	0.568	0.547	0.556	0.564	0.556	0.562	0.567	0.547	0.547	0.547	0.560	0.564	0.547	0.547	0.562	0.569	0.567	0.819
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.564	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.967
	IV	0.547	0.554	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.556	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.987
	Average	0.547	0.549	0.560	0.556	0.556	0.568	0.555	0.561	0.567	0.560	0.562	0.567	0.549	0.556	0.563	0.560	0.564	0.559	0.556	0.562	0.569	0.567	0.935
14	I	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.262	0.254	0.261	0.254	0.254	0.254	0.258	0.254	0.254	0.254	0.262	0.254	0.254	0.317
	II	0.547	0.547	0.556	0.558	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.957
	III	0.547	0.547	0.547	0.547	0.556	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.558	0.559	0.562	0.567	0.567	0.921
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.474	0.474	0.481	0.480	0.482	0.489	0.482	0.485	0.490	0.486	0.485	0.491	0.477	0.483	0.490	0.485	0.487	0.485	0.483	0.487	0.490	0.489	0.795
15	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.559	0.562	0.569	0.567	0.950
	II	0.547	0.559	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.982
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.563	0.559	0.562	0.569	0.567	0.968
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.554	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.559	0.569	0.560	0.564	0.559	0.559	0.562	0.569	0.567	0.975
16	I	0.547	0.547	0.547	0.547	0.554	0.568	0.557	0.562	0.569	0.561	0.562	0.567	0.547	0.557	0.569	0.560	0.564	0.547	0.547	0.562	0.569	0.567	0.892
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.562	0.559	0.562	0.569	0.567	0.967
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.551	0.561	0.556	0.558	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.559	0.569	0.560	0.564	0.559	0.556	0.562	0.569	0.567	0.957
17	I	0.547	0.547	0.547	0.547	0.547	0.564	0.547	0.550	0.561	0.560	0.552	0.567	0.547	0.547	0.559	0.560	0.557	0.547	0.547	0.562	0.547	0.567	0.780
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.562	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.560	0.559	0.562	0.567	0.567	0.960
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.560	0.556	0.556	0.567	0.555	0.559	0.567	0.561	0.560	0.567	0.550	0.556	0.566	0.560	0.562	0.559	0.556	0.562	0.563	0.567	0.923
																			Overall System Hydraulic Reliability					0.936

*) Refer to Table 4.11

Table E.2. Overall System Hydraulic Reliability Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Hyd Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.551	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.973
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.558	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.981
3	I	0.547	0.547	0.547	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.948
	II	0.547	0.547	0.547	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.963
	III	0.547	0.547	0.547	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.963
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.552	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.965
4	I	0.547	0.547	0.547	0.547	0.559	0.568	0.548	0.557	0.566	0.561	0.562	0.567	0.547	0.553	0.564	0.560	0.564	0.547	0.553	0.562	0.566	0.567	0.873
	II	0.547	0.547	0.547	0.556	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.959
	III	0.547	0.547	0.547	0.547	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.935
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.552	0.552	0.559	0.568	0.556	0.561	0.568	0.561	0.562	0.567	0.554	0.558	0.567	0.560	0.564	0.559	0.558	0.562	0.568	0.567	0.938
5	I	0.276	0.276	0.276	0.276	0.276	0.288	0.276	0.276	0.276	0.288	0.287	0.286	0.276	0.276	0.276	0.276	0.287	0.276	0.276	0.282	0.276	0.280	0.390
	II	0.547	0.547	0.547	0.555	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.943
	III	0.547	0.547	0.547	0.547	0.547	0.568	0.557	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.919
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.479	0.479	0.484	0.484	0.485	0.498	0.487	0.491	0.495	0.493	0.494	0.497	0.483	0.488	0.495	0.489	0.495	0.492	0.488	0.492	0.495	0.495	0.809
6	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	0.547	0.547	0.547	0.547	0.556	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.931
	III	0.547	0.547	0.547	0.547	0.547	0.556	0.551	0.558	0.567	0.561	0.562	0.567	0.547	0.557	0.569	0.560	0.564	0.554	0.557	0.562	0.567	0.567	0.874
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.410	0.697
7	I	0.547	0.547	0.565	0.559	0.559	0.568	0.547	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.956
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.547	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.971
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.565	0.559	0.559	0.568	0.552	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.973
8	I	0.547	0.547	0.547	0.547	0.554	0.568	0.547	0.547	0.569	0.561	0.562	0.567	0.547	0.556	0.567	0.560	0.564	0.554	0.556	0.562	0.568	0.567	0.879
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.551	0.562	0.569	0.561	0.562	0.567	0.554	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.967
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.561	0.556	0.558	0.568	0.553	0.558	0.569	0.561	0.562	0.567	0.555	0.559	0.568	0.560	0.564	0.561	0.559	0.562	0.568	0.567	0.953
9	I	0.278	0.278	0.278	0.278	0.278	0.289	0.278	0.278	0.278	0.278	0.286	0.288	0.278	0.278	0.278	0.278	0.287	0.278	0.278	0.283	0.278	0.285	0.374
	II	0.547	0.547	0.547	0.557	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.945
	III	0.547	0.547	0.547	0.547	0.553	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.563	0.559	0.562	0.569	0.567	0.926
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.480	0.480	0.484	0.485	0.487	0.498	0.488	0.491	0.496	0.490	0.493	0.497	0.483	0.489	0.496	0.490	0.495	0.492	0.489	0.492	0.496	0.497	0.807

Table E.2. Overall System Hydraulic Reliability Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Hyd Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	0.547	0.547	0.547	0.550	0.557	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.936
	III	0.547	0.547	0.547	0.547	0.547	0.568	0.553	0.560	0.569	0.561	0.554	0.567	0.547	0.558	0.569	0.560	0.564	0.550	0.556	0.562	0.565	0.567	0.879
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.410	0.410	0.415	0.414	0.416	0.426	0.417	0.421	0.426	0.421	0.420	0.425	0.414	0.419	0.426	0.420	0.423	0.419	0.419	0.422	0.426	0.425	0.700
11	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	III	0.547	0.554	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.976
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	Average	0.547	0.556	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.978
12	I	0.547	0.547	0.547	0.547	0.548	0.568	0.555	0.560	0.569	0.560	0.562	0.567	0.547	0.547	0.569	0.560	0.564	0.560	0.558	0.562	0.569	0.567	0.896
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.553	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.962
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	Average	0.547	0.551	0.561	0.556	0.557	0.568	0.557	0.562	0.569	0.561	0.562	0.567	0.547	0.555	0.569	0.560	0.564	0.563	0.559	0.562	0.569	0.567	0.953
13	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.013	0.007	0.034
	II	0.547	0.547	0.563	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.966
	III	0.547	0.547	0.547	0.553	0.557	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.550	0.567	0.560	0.564	0.557	0.558	0.562	0.569	0.567	0.917
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	Average	0.410	0.410	0.419	0.418	0.419	0.426	0.419	0.422	0.426	0.421	0.422	0.425	0.410	0.417	0.426	0.423	0.423	0.421	0.419	0.422	0.430	0.427	0.721
14	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	0.547	0.547	0.547	0.547	0.554	0.568	0.557	0.562	0.569	0.561	0.561	0.567	0.547	0.559	0.569	0.560	0.564	0.556	0.558	0.562	0.565	0.567	0.912
	III	0.547	0.547	0.547	0.547	0.547	0.565	0.547	0.555	0.564	0.561	0.547	0.567	0.547	0.555	0.565	0.560	0.555	0.547	0.547	0.562	0.547	0.566	0.799
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.553	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.975
	Average	0.410	0.410	0.415	0.413	0.415	0.425	0.416	0.420	0.425	0.421	0.418	0.425	0.412	0.418	0.426	0.420	0.421	0.417	0.416	0.422	0.420	0.425	0.671
15	I	0.547	0.547	0.547	0.555	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.559	0.562	0.569	0.567	0.924
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.562	0.559	0.562	0.569	0.567	0.966
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.559	0.562	0.569	0.567	0.950
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	Average	0.547	0.551	0.561	0.558	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.555	0.559	0.562	0.569	0.567	0.956
16	I	0.459	0.459	0.459	0.459	0.459	0.474	0.459	0.459	0.464	0.466	0.467	0.475	0.459	0.459	0.459	0.472	0.469	0.459	0.459	0.474	0.480	0.479	0.668
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.560	0.559	0.562	0.569	0.567	0.965
	III	0.547	0.547	0.561	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.556	0.562	0.569	0.567	0.941
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	Average	0.525	0.525	0.537	0.534	0.534	0.544	0.533	0.536	0.542	0.537	0.539	0.544	0.525	0.534	0.541	0.538	0.540	0.533	0.533	0.540	0.547	0.545	0.886
17	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.015
	II	0.547	0.547	0.560	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.558	0.559	0.562	0.566	0.567	0.954
	III	0.547	0.547	0.547	0.547	0.556	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.553	0.562	0.547	0.567	0.881
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	Average	0.410	0.410	0.418	0.416	0.419	0.426	0.418	0.422	0.426	0.421	0.422	0.425	0.410	0.420	0.426	0.420	0.423	0.417	0.418	0.422	0.420	0.429	0.705
																			Overall System Hydraulic Reliability					0.847

*) Refer to Table 4.11

Table E.3. Overall System Hydraulic Reliability Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Hyd Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
3	I	0.547	0.547	0.547	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.963
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.561	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.978
4	I	0.547	0.547	0.547	0.547	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.937
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.561	0.556	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.558	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.972
5	I	0.547	0.547	0.547	0.547	0.554	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.928
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.561	0.556	0.558	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.970
6	I	0.547	0.547	0.547	0.547	0.547	0.560	0.554	0.560	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.557	0.558	0.562	0.569	0.567	0.895
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.563	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.554	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.974
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.959
7	I	0.547	0.547	0.565	0.559	0.559	0.568	0.552	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.976
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.565	0.559	0.559	0.568	0.556	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.982
8	I	0.547	0.547	0.565	0.559	0.559	0.568	0.554	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.975
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.565	0.559	0.559	0.568	0.557	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.981
9	I	0.547	0.547	0.547	0.547	0.556	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.931
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.551	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.973
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.561	0.556	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.555	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968

Table E.3. Overall System Hydraulic Reliability Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Hyd Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	0.547	0.547	0.547	0.547	0.547	0.568	0.555	0.562	0.569	0.561	0.557	0.567	0.547	0.559	0.569	0.560	0.564	0.555	0.558	0.562	0.567	0.567	0.898
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.971
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.561	0.556	0.556	0.568	0.557	0.562	0.569	0.561	0.561	0.567	0.554	0.559	0.569	0.560	0.564	0.562	0.559	0.562	0.568	0.567	0.959
11	I	0.547	0.558	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.980
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.561	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.988
12	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.556	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.965
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	III	0.547	0.554	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.977
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.556	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.982
13	I	0.547	0.547	0.547	0.556	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.554	0.569	0.560	0.564	0.560	0.559	0.562	0.569	0.567	0.933
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.551	0.561	0.558	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.558	0.569	0.560	0.564	0.563	0.559	0.562	0.569	0.567	0.967
14	I	0.547	0.547	0.547	0.547	0.547	0.567	0.551	0.558	0.567	0.561	0.549	0.567	0.547	0.557	0.568	0.560	0.559	0.547	0.551	0.562	0.547	0.567	0.828
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.552	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.974
	III	0.547	0.547	0.561	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.964
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.560	0.556	0.556	0.568	0.556	0.561	0.568	0.561	0.559	0.567	0.552	0.559	0.568	0.560	0.563	0.559	0.557	0.562	0.563	0.567	0.937
15	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.559	0.562	0.569	0.567	0.950
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.559	0.569	0.560	0.564	0.559	0.559	0.562	0.569	0.567	0.980
16	I	0.547	0.547	0.563	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.558	0.562	0.569	0.567	0.946
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.551	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.559	0.569	0.560	0.564	0.559	0.559	0.562	0.569	0.567	0.971
17	I	0.547	0.547	0.547	0.552	0.558	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.556	0.562	0.547	0.567	0.892
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.551	0.561	0.557	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.559	0.569	0.560	0.564	0.559	0.559	0.562	0.563	0.567	0.957
																			Overall System Hydraulic Reliability					0.971

*) Refer to Table 4.11

Table E.4. Overall System Hydraulic Reliability Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand	State*																						Ov. Nodal
	Pattern	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Hyd Rel.
2	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.551	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.973
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.558	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.981
3	I	0.547	0.547	0.547	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.563	0.559	0.562	0.569	0.567	0.948
	II	0.547	0.547	0.547	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.963
	III	0.547	0.547	0.547	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.552	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.954
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.552	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.555	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.962
4	I	0.547	0.547	0.547	0.547	0.559	0.568	0.547	0.556	0.565	0.561	0.562	0.567	0.547	0.553	0.564	0.560	0.564	0.547	0.553	0.562	0.565	0.567	0.870
	II	0.547	0.547	0.547	0.547	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.555	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.943
	III	0.547	0.547	0.547	0.547	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.935
	IV	0.547	0.547	0.564	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.551	0.550	0.559	0.568	0.555	0.561	0.568	0.561	0.562	0.567	0.552	0.558	0.567	0.560	0.564	0.559	0.558	0.562	0.568	0.567	0.933
5	I	0.261	0.261	0.261	0.261	0.261	0.273	0.261	0.261	0.261	0.273	0.272	0.271	0.261	0.261	0.261	0.261	0.272	0.261	0.261	0.268	0.261	0.264	0.369
	II	0.547	0.547	0.547	0.547	0.556	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.931
	III	0.547	0.547	0.547	0.547	0.547	0.568	0.547	0.555	0.565	0.561	0.562	0.567	0.547	0.556	0.566	0.560	0.564	0.554	0.556	0.562	0.567	0.567	0.873
	IV	0.547	0.547	0.563	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.978
	Average	0.476	0.476	0.480	0.479	0.481	0.494	0.481	0.485	0.491	0.489	0.490	0.493	0.478	0.484	0.491	0.486	0.491	0.486	0.484	0.488	0.491	0.491	0.788
6	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	0.547	0.547	0.547	0.547	0.547	0.562	0.555	0.561	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.559	0.558	0.562	0.569	0.567	0.902
	III	0.422	0.422	0.422	0.422	0.422	0.422	0.422	0.422	0.422	0.435	0.428	0.439	0.422	0.422	0.429	0.431	0.437	0.422	0.422	0.434	0.422	0.435	0.580
	IV	0.547	0.547	0.558	0.557	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.958
	Average	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.610
7	I	0.547	0.547	0.565	0.559	0.559	0.568	0.547	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.563	0.559	0.562	0.569	0.567	0.956
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.554	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.978
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.547	0.562	0.569	0.561	0.562	0.567	0.553	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.963
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.565	0.559	0.559	0.568	0.551	0.562	0.569	0.561	0.562	0.567	0.555	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.970
8	I	0.547	0.547	0.547	0.547	0.554	0.568	0.547	0.547	0.569	0.561	0.562	0.567	0.547	0.556	0.567	0.560	0.564	0.553	0.556	0.562	0.568	0.567	0.877
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.555	0.562	0.569	0.561	0.562	0.567	0.558	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.978
	III	0.547	0.547	0.564	0.559	0.559	0.568	0.547	0.551	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.942
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.560	0.556	0.558	0.568	0.552	0.556	0.569	0.561	0.562	0.567	0.553	0.559	0.568	0.560	0.564	0.561	0.559	0.562	0.568	0.567	0.945
9	I	0.264	0.264	0.264	0.264	0.264	0.274	0.264	0.264	0.264	0.264	0.272	0.273	0.264	0.264	0.264	0.264	0.272	0.264	0.264	0.268	0.264	0.270	0.354
	II	0.547	0.547	0.547	0.550	0.557	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.935
	III	0.547	0.547	0.547	0.547	0.547	0.568	0.549	0.557	0.567	0.552	0.562	0.567	0.547	0.551	0.564	0.560	0.564	0.551	0.556	0.562	0.569	0.567	0.858
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	Average	0.476	0.476	0.481	0.480	0.482	0.494	0.482	0.486	0.492	0.484	0.490	0.494	0.476	0.483	0.491	0.486	0.491	0.485	0.484	0.489	0.492	0.493	0.779

Table E.4. Overall System Hydraulic Reliability Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Hyd Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	0.547	0.547	0.547	0.547	0.551	0.568	0.556	0.562	0.569	0.561	0.559	0.567	0.547	0.559	0.569	0.560	0.564	0.559	0.559	0.562	0.568	0.567	0.913
	III	0.471	0.471	0.471	0.471	0.471	0.481	0.471	0.471	0.479	0.484	0.471	0.487	0.471	0.471	0.481	0.481	0.487	0.471	0.471	0.484	0.471	0.485	0.660
	IV	0.547	0.547	0.560	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.963
	Average	0.391	0.391	0.395	0.394	0.395	0.404	0.396	0.399	0.404	0.401	0.398	0.405	0.391	0.397	0.405	0.401	0.404	0.398	0.397	0.402	0.402	0.405	0.634
11	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	II	0.547	0.559	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.982
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	Average	0.547	0.554	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.976
12	I	0.547	0.547	0.547	0.547	0.547	0.568	0.555	0.560	0.569	0.560	0.562	0.567	0.547	0.547	0.569	0.560	0.564	0.560	0.558	0.562	0.569	0.567	0.894
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.557	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.966
	III	0.547	0.547	0.561	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.547	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.950
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	Average	0.547	0.547	0.560	0.556	0.556	0.568	0.557	0.562	0.569	0.561	0.562	0.567	0.547	0.553	0.569	0.560	0.564	0.563	0.559	0.562	0.569	0.567	0.945
13	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.000	0.013	0.007	0.033
	II	0.547	0.547	0.555	0.556	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.555	0.569	0.560	0.564	0.561	0.559	0.562	0.569	0.567	0.945
	III	0.547	0.547	0.547	0.547	0.547	0.567	0.551	0.556	0.563	0.556	0.561	0.566	0.547	0.547	0.547	0.560	0.562	0.547	0.547	0.560	0.568	0.567	0.822
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	Average	0.410	0.410	0.417	0.416	0.416	0.426	0.417	0.420	0.425	0.419	0.421	0.425	0.410	0.415	0.421	0.423	0.423	0.418	0.416	0.421	0.430	0.427	0.692
14	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	II	0.547	0.547	0.547	0.547	0.547	0.567	0.553	0.559	0.567	0.561	0.554	0.567	0.547	0.557	0.567	0.560	0.559	0.547	0.553	0.562	0.556	0.567	0.849
	III	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.303	0.295	0.304	0.295	0.295	0.295	0.301	0.295	0.295	0.295	0.303	0.295	0.295	0.370
	IV	0.547	0.547	0.554	0.556	0.558	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.562	0.559	0.562	0.569	0.567	0.950
	Average	0.347	0.347	0.349	0.349	0.350	0.357	0.351	0.354	0.357	0.356	0.353	0.360	0.347	0.353	0.358	0.355	0.354	0.351	0.352	0.357	0.355	0.357	0.542
15	I	0.547	0.547	0.547	0.555	0.558	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.559	0.562	0.569	0.567	0.923
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.554	0.559	0.562	0.569	0.567	0.958
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.559	0.562	0.569	0.567	0.950
	IV	0.547	0.560	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.550	0.561	0.558	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.553	0.559	0.562	0.569	0.567	0.953
16	I	0.451	0.451	0.451	0.451	0.451	0.466	0.451	0.451	0.455	0.458	0.459	0.467	0.451	0.451	0.451	0.464	0.461	0.451	0.451	0.466	0.473	0.471	0.656
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.552	0.559	0.562	0.569	0.567	0.954
	III	0.547	0.547	0.547	0.551	0.556	0.568	0.557	0.562	0.569	0.561	0.562	0.567	0.547	0.558	0.569	0.560	0.564	0.547	0.547	0.562	0.569	0.567	0.901
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	Average	0.523	0.523	0.532	0.530	0.532	0.542	0.531	0.534	0.540	0.535	0.537	0.542	0.523	0.532	0.539	0.536	0.538	0.528	0.529	0.538	0.545	0.543	0.870
17	I	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.015
	II	0.547	0.547	0.547	0.555	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.557	0.562	0.556	0.567	0.908
	III	0.547	0.547	0.547	0.547	0.547	0.565	0.550	0.556	0.564	0.561	0.557	0.567	0.547	0.553	0.563	0.560	0.560	0.547	0.547	0.562	0.547	0.567	0.814
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	Average	0.410	0.410	0.415	0.415	0.416	0.425	0.416	0.420	0.425	0.421	0.420	0.425	0.410	0.418	0.425	0.420	0.422	0.414	0.416	0.422	0.418	0.429	0.676
																			Overall System Hydraulic Reliability					0.814

*) Refer to Table 4.11

Table E.5. Overall System Hydraulic Reliability Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Hyd Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
3	I	0.547	0.547	0.547	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.948
	II	0.547	0.547	0.564	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.982
	III	0.547	0.547	0.547	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.963
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.556	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.969
4	I	0.547	0.547	0.547	0.547	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.935
	II	0.547	0.547	0.562	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.980
	III	0.547	0.547	0.547	0.554	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.558	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.954
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.555	0.555	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.556	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.963
5	I	0.547	0.547	0.547	0.547	0.547	0.568	0.547	0.547	0.562	0.561	0.562	0.567	0.547	0.554	0.565	0.560	0.564	0.547	0.554	0.562	0.566	0.567	0.847
	II	0.547	0.547	0.561	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.555	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.973
	III	0.547	0.547	0.547	0.551	0.558	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.938
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.555	0.554	0.556	0.568	0.555	0.558	0.567	0.561	0.562	0.567	0.552	0.558	0.568	0.560	0.564	0.559	0.558	0.562	0.568	0.567	0.935
6	I	0.407	0.407	0.407	0.407	0.407	0.407	0.407	0.407	0.407	0.419	0.407	0.423	0.407	0.407	0.407	0.414	0.422	0.407	0.407	0.417	0.407	0.418	0.545
	II	0.547	0.547	0.554	0.557	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.954
	III	0.547	0.547	0.547	0.547	0.553	0.565	0.556	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.562	0.559	0.562	0.569	0.567	0.920
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.512	0.851
7	I	0.547	0.547	0.565	0.559	0.559	0.568	0.547	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.956
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.556	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.981
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.565	0.559	0.559	0.568	0.555	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.976
8	I	0.547	0.547	0.563	0.559	0.559	0.568	0.547	0.547	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.937
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.557	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.982
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.564	0.559	0.559	0.568	0.555	0.558	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.971
9	I	0.547	0.547	0.547	0.547	0.547	0.568	0.547	0.552	0.564	0.547	0.562	0.567	0.547	0.547	0.560	0.560	0.564	0.547	0.552	0.562	0.569	0.567	0.827
	II	0.547	0.547	0.564	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.967
	III	0.547	0.547	0.547	0.554	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.943
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.547	0.556	0.555	0.556	0.568	0.555	0.560	0.567	0.557	0.562	0.567	0.550	0.556	0.566	0.560	0.564	0.559	0.558	0.562	0.569	0.567	0.930

Table E.5. Overall System Hydraulic Reliability Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Hyd Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.463	0.450	0.465	0.450	0.450	0.450	0.459	0.467	0.450	0.450	0.462	0.450	0.462	0.598
	II	0.547	0.547	0.558	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.960
	III	0.547	0.547	0.547	0.547	0.555	0.568	0.558	0.562	0.569	0.561	0.561	0.567	0.547	0.559	0.569	0.560	0.564	0.561	0.559	0.562	0.569	0.567	0.925
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.523	0.523	0.530	0.529	0.531	0.538	0.531	0.534	0.539	0.536	0.534	0.542	0.526	0.532	0.539	0.535	0.540	0.535	0.532	0.537	0.539	0.541	0.867
11	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	III	0.547	0.561	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.984
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.551	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.990
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.548	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.982
12	I	0.547	0.547	0.559	0.558	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.547	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.947
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.551	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.990
	Average	0.547	0.551	0.563	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.548	0.556	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
13	I	0.547	0.547	0.547	0.547	0.547	0.568	0.547	0.555	0.564	0.556	0.562	0.567	0.547	0.547	0.547	0.560	0.564	0.547	0.547	0.562	0.569	0.567	0.818
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.559	0.558	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.557	0.569	0.560	0.564	0.563	0.559	0.562	0.569	0.567	0.957
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	Average	0.547	0.547	0.559	0.556	0.556	0.568	0.555	0.561	0.567	0.560	0.562	0.567	0.547	0.556	0.563	0.560	0.564	0.559	0.556	0.562	0.569	0.567	0.928
14	I	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.257	0.250	0.256	0.250	0.250	0.250	0.253	0.250	0.250	0.250	0.257	0.250	0.250	0.311
	II	0.547	0.547	0.547	0.556	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.563	0.559	0.562	0.569	0.567	0.944
	III	0.547	0.547	0.547	0.547	0.548	0.568	0.555	0.561	0.569	0.561	0.558	0.567	0.547	0.559	0.569	0.560	0.562	0.547	0.556	0.562	0.560	0.567	0.877
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.980
	Average	0.473	0.473	0.477	0.478	0.479	0.488	0.480	0.484	0.489	0.485	0.483	0.489	0.475	0.482	0.489	0.484	0.485	0.481	0.481	0.486	0.487	0.488	0.778
15	I	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.559	0.562	0.569	0.567	0.950
	II	0.547	0.556	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.978
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.559	0.559	0.562	0.569	0.567	0.963
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.556	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
	Average	0.547	0.553	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.550	0.559	0.569	0.560	0.564	0.558	0.559	0.562	0.569	0.567	0.972
16	I	0.547	0.547	0.547	0.547	0.553	0.568	0.557	0.562	0.569	0.561	0.562	0.567	0.547	0.557	0.569	0.560	0.564	0.547	0.547	0.562	0.569	0.567	0.891
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.557	0.559	0.562	0.569	0.567	0.961
	IV	0.547	0.558	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.555	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.989
	Average	0.547	0.550	0.561	0.556	0.558	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.549	0.559	0.569	0.560	0.564	0.558	0.556	0.562	0.569	0.567	0.953
17	I	0.547	0.547	0.547	0.547	0.547	0.564	0.547	0.550	0.561	0.560	0.552	0.567	0.547	0.547	0.559	0.560	0.557	0.547	0.547	0.562	0.547	0.567	0.779
	II	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.968
	III	0.547	0.547	0.556	0.557	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.554	0.559	0.562	0.561	0.567	0.936
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.554	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.976
	Average	0.547	0.547	0.558	0.556	0.556	0.567	0.555	0.559	0.567	0.561	0.560	0.567	0.549	0.556	0.566	0.560	0.562	0.557	0.556	0.562	0.561	0.567	0.915
																			Overall System Hydraulic Reliability					0.932

*) Refer to Table 4.11

Table F.1. Water Quality Reliability Under Average Demand During Various Demand Patterns

Node	Demand Pattern	State*																																												Average	
		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22			
		CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ
2	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.66	1	0.48	1	0.65	1	0.65	1	0.65	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.68	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.65	1
	III	0.32	1	0.22	1	0.31	1	0.31	1	0.31	1	0.32	1	0.31	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.33	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.31	1
	IV	0.46	1	0.11	0	0.45	1	0.45	1	0.45	1	0.46	1	0.46	1	0.46	1	0.46	1	0.46	1	0.46	1	0.46	1	0.47	1	0.46	1	0.46	1	0.46	1	0.46	1	0.47	1	0.46	1	0.46	1	0.46	1	0.46	1	0.44	1
	Average	0.61	1	0.45	1	0.60	1	0.60	1	0.60	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.62	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.60	1
3	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.59	1	0.46	1	0.39	1	0.41	1	0.50	1	0.59	1	0.60	1	0.60	1	0.60	1	0.58	1	0.59	1	0.59	1	0.63	1	0.60	1	0.60	1	0.59	1	0.59	1	0.60	1	0.60	1	0.59	1	0.60	1	0.59	1	0.57	1
	III	0.26	1	0.19	0	0.30	1	0.34	1	0.20	1	0.26	1	0.28	1	0.27	1	0.27	1	0.26	1	0.26	1	0.26	1	0.30	1	0.27	1	0.27	1	0.26	1	0.26	1	0.28	1	0.27	1	0.26	1	0.27	1	0.26	1	0.27	1
	IV	0.39	1	0.28	1	0.21	1	0.17	0	0.31	1	0.39	1	0.41	1	0.41	1	0.40	1	0.39	1	0.39	1	0.39	1	0.43	1	0.40	1	0.40	1	0.39	1	0.39	1	0.41	1	0.40	1	0.39	1	0.40	1	0.39	1	0.37	1
	Average	0.56	1	0.48	1	0.48	1	0.48	1	0.50	1	0.56	1	0.57	1	0.57	1	0.57	1	0.56	1	0.56	1	0.56	1	0.59	1	0.57	1	0.57	1	0.56	1	0.56	1	0.57	1	0.57	1	0.56	1	0.57	1	0.56	1	0.55	1
4	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.55	1	0.53	1	0.49	1	0.43	1	0.39	1	0.55	1	0.58	1	0.57	1	0.57	1	0.54	1	0.54	1	0.55	1	0.60	1	0.57	1	0.56	1	0.55	1	0.55	1	0.57	1	0.57	1	0.55	1	0.56	1	0.55	1	0.54	1
	III	0.23	1	0.22	1	0.20	1	0.18	0	0.31	1	0.23	1	0.25	1	0.25	1	0.25	1	0.23	1	0.23	1	0.23	1	0.28	1	0.25	1	0.24	1	0.24	1	0.23	1	0.25	1	0.25	1	0.23	1	0.23	1	0.23	1	0.24	1
	IV	0.36	1	0.34	1	0.30	1	0.26	1	0.15	0	0.35	1	0.38	1	0.38	1	0.37	1	0.34	1	0.35	1	0.35	1	0.41	1	0.37	1	0.37	1	0.36	1	0.35	1	0.37	1	0.37	1	0.36	1	0.36	1	0.36	1	0.35	1
	Average	0.54	1	0.52	1	0.50	1	0.47	1	0.46	1	0.53	1	0.55	1	0.55	1	0.55	1	0.53	1	0.53	1	0.53	1	0.57	1	0.55	1	0.54	1	0.54	1	0.53	1	0.55	1	0.55	1	0.54	1	0.54	1	0.54	1	0.53	1
5	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.50	1	0.57	1	0.54	1	0.53	1	0.54	1	0.50	1	0.55	1	0.55	1	0.54	1	0.49	1	0.50	1	0.50	1	0.57	1	0.53	1	0.52	1	0.50	1	0.50	1	0.54	1	0.52	1	0.50	1	0.51	1	0.50	1	0.52	1
	III	0.20	1	0.25	1	0.22	1	0.23	1	0.23	1	0.20	1	0.24	1	0.24	1	0.23	1	0.20	1	0.20	1	0.20	1	0.26	1	0.22	1	0.21	1	0.21	1	0.20	1	0.22	1	0.22	1	0.20	1	0.22	1	0.21	1	0.22	1
	IV	0.31	1	0.38	1	0.35	1	0.34	1	0.34	1	0.31	1	0.36	1	0.36	1	0.35	1	0.30	1	0.31	1	0.31	1	0.39	1	0.34	1	0.33	1	0.32	1	0.31	1	0.34	1	0.34	1	0.31	1	0.33	1	0.32	1	0.33	1
	Average	0.50	1	0.55	1	0.53	1	0.53	1	0.53	1	0.50	1	0.54	1	0.54	1	0.53	1	0.50	1	0.50	1	0.50	1	0.56	1	0.52	1	0.52	1	0.51	1	0.50	1	0.53	1	0.52	1	0.50	1	0.52	1	0.51	1	0.52	1
6	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.42	1	0.40	1	0.41	1	0.42	1	0.43	1	0.39	1	0.45	1	0.45	1	0.45	1	0.41	1	0.44	1	0.40	1	0.51	1	0.44	1	0.43	1	0.41	1	0.40	1	0.46	1	0.45	1	0.41	1	0.45	1	0.42	1	0.43	1
	III	0.21	1	0.19	0	0.16	0	0.18	0	0.16	0	0.21	1	0.17	0	0.17	0	0.16	0	0.27	1	0.16	0	0.30	1	0.21	1	0.16	0	0.16	0	0.19	0	0.29	1	0.18	0	0.17	0	0.22	1	0.17	0	0.16	0	0.19	0
	IV	0.24	1	0.23	1	0.23	1	0.24	1	0.25	1	0.22	1	0.27	1	0.27	1	0.26	1	0.24	1	0.26	1	0.23	1	0.33	1	0.26	1	0.26	1	0.24	1	0.23	1	0.28	1	0.27	1	0.24	1	0.26	1	0.25	1	0.25	1
	Average	0.47	1	0.46	1	0.45	1	0.46	1	0.46	1	0.46	1	0.47	1	0.47	1	0.47	1	0.48	1	0.47	1	0.48	1	0.51	1	0.47	1	0.46	1	0.46	1	0.48	1	0.48	1	0.47	1	0.47	1	0.47	1	0.46	1	0.47	1
7	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.61	1	0.40	1	0.62	1	0.62	1	0.62	1	0.61	1	0.37	1	0.51	1	0.57	1	0.61	1	0.61	1	0.61	1	0.64	1	0.62	1	0.62	1	0.61	1	0.61	1	0.63	1	0.62	1	0.61	1	0.62	1	0.61	1	0.59	1
	III	0.28	1	0.28	1	0.29	1	0.29	1	0.29	1	0.28	1	0.28	1	0.21	1	0.25	1	0.28	1	0.28	1	0.28	1	0.31	1	0.29	1	0.29	1	0.28	1	0.28	1	0.29	1	0.29	1	0.28	1	0.29	1	0.28	1	0.28	1
	IV	0.41	1	0.16	0	0.42	1	0.42	1	0.42	1	0.41	1	0.21	1	0.32	1	0.38	1	0.41	1	0.41	1	0.41	1	0.45	1	0.42	1	0.42	1	0.42	1	0.41	1	0.43	1	0.42	1	0.41	1	0.42	1	0.42	1	0.39	1
	Average	0.58	1	0.46	1	0.58	1	0.58	1	0.58	1	0.58	1	0.47	1	0.51	1	0.55	1	0.58	1	0.58	1	0.58	1	0.60	1	0.58	1	0.58	1	0.58	1	0.58	1	0.59	1	0.58	1	0.58	1	0.58	1	0.58	1	0.57	1
8	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.55	1	0.48	1	0.59	1	0.58	1	0.59	1	0.55	1	0.48	1	0.42	1	0.44	1	0.54	1	0.55	1	0.55	1	0.60	1	0.57	1	0.57	1	0.56	1	0.55	1	0.57	1	0.57	1	0.55	1	0.57	1	0.55	1	0.54	1
	III	0.24	1	0.19	0	0.26	1	0.26	1	0.26	1	0.24	1	0.19	0	0.17	0	0.25	1	0.23	1	0.24	1	0.24	1	0.28	1	0.25	1	0.25	1	0.24	1	0.24	1	0.25	1	0.25	1	0.24	1	0.25	1	0.24	1	0.24	1
	IV	0.36	1	0.30	1	0.39	1	0.39	1	0.39	1	0.36	1	0.30	1	0.25	1	0.27	1	0.35	1	0.36	1	0.36	1	0.41	1	0.37	1	0.37	1	0.36	1	0.36	1	0.38	1	0.37	1	0.36	1	0.37	1	0.36	1	0.35	1
	Average	0.54	1	0.49	1	0.56	1	0.56	1	0.56	1	0.54	1	0.49	1	0.46	1	0.49	1	0.53	1	0.54	1	0.54	1	0.57	1	0.55	1	0.55	1	0.54	1	0.54	1	0.55	1	0.55	1	0.54	1	0.55	1	0.54	1	0.53	1
9	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.42	1	0.62	1	0.54	1	0.58	1	0.52	1	0.42	1	0.49	1	0.46	1	0.45	1	0.50	1	0.42	1	0.42	1	0.55	1	0.48	1	0.47	1	0.45	1	0.42	1	0.48	1	0.46	1	0.43	1	0.46	1	0.42	1	0.47	1
	III	0.23	1	0.28	1	0.23	1	0.22	1	0.21	1	0.18	0	0.20	1	0.21	1	0.23	1	0.20	1	0.17	0	0.21	1	0.24	1	0.19	0	0.18	0	0.17	0	0.16	0	0.19	0	0.18	0	0.16	0	0.18	0	0.23	1	0.20	1
	IV	0.25	1	0.41	1	0.35	1	0.34	1	0.33	1	0.25	1	0.29	1	0.28	1	0.27	1	0.31	1	0.24	1	0.25	1	0.36	1	0.30	1	0.28	1	0.27	1	0.25	1	0.29	1	0.28	1	0.25	1	0.27	1	0.25	1	0.29	1
	Average	0.48	1	0.58	1	0.53	1	0.52	1	0.52	1	0.46	1	0.50	1	0.49	1	0.49	1	0.50	1	0.46	1	0.47	1	0.54	1	0.49	1	0.48	1	0.47	1	0.46	1	0.49	1	0.48	1	0.46	1	0.48	1	0.48	1	0.49	1
10	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.42	1	0.55	1	0.42	1	0.41	1	0.47	1	0.46	1	0.47	1	0.46	1	0.45	1	0.42	1	0.39	1	0.45	1	0.52	1	0.44	1	0.44	1	0.44	1	0.43	1	0.47	1	0.45	1	0.42	1	0.45	1	0.43	1	0.45	1
	III	0.17	0	0.23	1	0.20	1	0.19	0	0.20	1	0.17	0	0.19	0	0.19	0	0.19	0	0.17	0	0.26	1	0.17	0	0.22	1	0.18	0	0.18	0	0.16	0	0.17	0	0.21	1	0.20	1	0.17	0	0.20	1	0.18	0	0.19	0
	IV	0.24	1	0.36	1	0.25	1	0.24	1	0.27	1	0.28	1	0.29	1	0.28	1	0.27	1	0.23	1	0.20	1	0.26	1	0.34	1	0.26	1	0.25	1	0.25	1	0.24	1	0.29	1	0.28	1	0.24	1	0.27	1	0.24	1	0.27	1
	Average	0.46	1	0.54	1	0.47	1	0.46	1	0.49	1	0.48	1	0.49	1	0.48	1	0.48	1	0.46	1	0.46	1	0.47	1	0.52	1	0.47	1	0.47	1	0.46	1	0.46	1	0.49	1	0.48	1	0.46	1	0.48	1	0.46	1	0.48	1

Table F.1. Water Quality Reliability Under Average Demand During Various Demand Patterns

Node	Demand Pattern	State*																																												Average	
		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22			
		CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ
11	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.66	1	0.68	1	0.67	1	0.67	1	0.67	1	0.66	1	0.67	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.38	1	0.66	1	0.66	1	0.66	1	0.66	1	0.65	1	0.66	1	0.66	1	0.66	1	0.66	1	0.65	1
	III	0.32	1	0.33	1	0.33	1	0.33	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.22	1	0.31	1	0.32	1	0.32	1	0.32	1	0.31	1	0.31	1	0.32	1	0.32	1	0.32	1	0.32	1
	IV	0.46	1	0.48	1	0.47	1	0.47	1	0.47	1	0.46	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.46	1	0.15	0	0.46	1	0.46	1	0.46	1	0.46	1	0.45	1	0.46	1	0.46	1	0.46	1	0.46	1	0.45	1
	Average	0.61	1	0.62	1	0.62	1	0.62	1	0.62	1	0.61	1	0.62	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.44	1	0.61	1	0.61	1	0.61	1	0.61	1	0.60	1	0.61	1	0.61	1	0.61	1	0.61	1	0.60	1
12	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.63	1	0.67	1	0.64	1	0.64	1	0.64	1	0.63	1	0.63	1	0.63	1	0.63	1	0.63	1	0.63	1	0.63	1	0.44	1	0.38	1	0.57	1	0.62	1	0.63	1	0.62	1	0.63	1	0.63	1	0.62	1	0.63	1	0.61	1
	III	0.28	1	0.32	1	0.30	1	0.30	1	0.29	1	0.29	1	0.30	1	0.30	1	0.30	1	0.30	1	0.29	1	0.28	1	0.17	0	0.18	0	0.25	1	0.29	1	0.29	1	0.28	1	0.29	1	0.28	1	0.28	1	0.28	1	0.28	1
	IV	0.43	1	0.46	1	0.45	1	0.44	1	0.44	1	0.43	1	0.44	1	0.44	1	0.43	1	0.44	1	0.43	1	0.43	1	0.27	1	0.22	1	0.37	1	0.43	1	0.43	1	0.43	1	0.43	1	0.43	1	0.42	1	0.43	1	0.41	1
	Average	0.59	1	0.61	1	0.60	1	0.60	1	0.59	1	0.59	1	0.59	1	0.59	1	0.59	1	0.59	1	0.59	1	0.59	1	0.47	1	0.45	1	0.55	1	0.59	1	0.59	1	0.58	1	0.59	1	0.59	1	0.58	1	0.59	1	0.58	1
13	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.51	1	0.63	1	0.57	1	0.56	1	0.55	1	0.52	1	0.54	1	0.54	1	0.53	1	0.53	1	0.54	1	0.52	1	0.54	1	0.50	1	0.47	1	0.52	1	0.54	1	0.56	1	0.57	1	0.55	1	0.51	1	0.51	1	0.54	1
	III	0.21	1	0.29	1	0.25	1	0.24	1	0.24	1	0.23	1	0.23	1	0.23	1	0.22	1	0.23	1	0.23	1	0.21	1	0.22	1	0.20	1	0.23	1	0.22	1	0.23	1	0.24	1	0.24	1	0.23	1	0.20	1	0.21	1	0.23	1
	IV	0.33	1	0.43	1	0.38	1	0.37	1	0.36	1	0.33	1	0.36	1	0.35	1	0.34	1	0.35	1	0.35	1	0.33	1	0.35	1	0.32	1	0.30	1	0.34	1	0.35	1	0.36	1	0.37	1	0.35	1	0.32	1	0.33	1	0.35	1
	Average	0.51	1	0.59	1	0.55	1	0.54	1	0.54	1	0.52	1	0.53	1	0.53	1	0.52	1	0.53	1	0.53	1	0.52	1	0.53	1	0.51	1	0.50	1	0.52	1	0.53	1	0.54	1	0.55	1	0.53	1	0.51	1	0.51	1	0.53	1
14	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.33	1	0.59	1	0.48	1	0.46	1	0.45	1	0.39	1	0.43	1	0.40	1	0.36	1	0.33	1	0.43	1	0.33	1	0.49	1	0.34	1	0.33	1	0.35	1	0.42	1	0.42	1	0.39	1	0.33	1	0.41	1	0.35	1	0.40	1
	III	0.23	1	0.26	1	0.19	0	0.18	0	0.17	0	0.15	0	0.16	0	0.16	0	0.16	0	0.22	1	0.16	0	0.24	1	0.19	0	0.24	1	0.23	1	0.16	0	0.15	0	0.17	0	0.17	0	0.23	1	0.17	0	0.25	1	0.19	0
	IV	0.14	0	0.39	1	0.30	1	0.28	1	0.26	1	0.19	0	0.23	1	0.20	1	0.18	0	0.17	0	0.25	1	0.15	0	0.31	1	0.17	0	0.15	0	0.17	0	0.25	1	0.24	1	0.21	1	0.16	0	0.23	1	0.18	0	0.22	1
	Average	0.43	1	0.56	1	0.49	1	0.48	1	0.47	1	0.43	1	0.46	1	0.44	1	0.43	1	0.43	1	0.46	1	0.43	1	0.50	1	0.44	1	0.43	1	0.42	1	0.46	1	0.46	1	0.44	1	0.43	1	0.45	1	0.45	1	0.45	1
15	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.60	1	0.65	1	0.63	1	0.63	1	0.62	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.60	1	0.36	1	0.61	1	0.61	1	0.60	1	0.61	1	0.45	1	0.49	1	0.60	1	0.59	1	0.60	1	0.59	1
	III	0.28	1	0.31	1	0.29	1	0.29	1	0.29	1	0.28	1	0.29	1	0.28	1	0.28	1	0.28	1	0.28	1	0.28	1	0.20	1	0.28	1	0.28	1	0.28	1	0.28	1	0.18	0	0.20	1	0.28	1	0.26	1	0.28	1	0.27	1
	IV	0.41	1	0.46	1	0.43	1	0.43	1	0.42	1	0.41	1	0.42	1	0.42	1	0.42	1	0.42	1	0.41	1	0.41	1	0.19	0	0.42	1	0.41	1	0.41	1	0.41	1	0.27	1	0.31	1	0.41	1	0.39	1	0.41	1	0.40	1
	Average	0.57	1	0.61	1	0.59	1	0.59	1	0.58	1	0.58	1	0.58	1	0.58	1	0.58	1	0.58	1	0.58	1	0.57	1	0.44	1	0.58	1	0.58	1	0.57	1	0.58	1	0.48	1	0.50	1	0.57	1	0.56	1	0.57	1	0.56	1
16	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.57	1	0.64	1	0.61	1	0.60	1	0.59	1	0.57	1	0.59	1	0.57	1	0.57	1	0.57	1	0.56	1	0.57	1	0.39	1	0.59	1	0.58	1	0.55	1	0.57	1	0.53	1	0.52	1	0.56	1	0.54	1	0.56	1	0.56	1
	III	0.25	1	0.30	1	0.27	1	0.27	1	0.26	1	0.25	1	0.26	1	0.26	1	0.26	1	0.25	1	0.25	1	0.25	1	0.16	0	0.26	1	0.26	1	0.25	1	0.25	1	0.23	1	0.21	1	0.24	1	0.23	1	0.24	1	0.25	1
	IV	0.37	1	0.44	1	0.41	1	0.40	1	0.39	1	0.38	1	0.39	1	0.39	1	0.38	1	0.38	1	0.37	1	0.37	1	0.23	1	0.39	1	0.38	1	0.36	1	0.37	1	0.33	1	0.32	1	0.37	1	0.35	1	0.37	1	0.37	1
	Average	0.55	1	0.60	1	0.57	1	0.57	1	0.56	1	0.55	1	0.56	1	0.56	1	0.55	1	0.55	1	0.55	1	0.55	1	0.45	1	0.56	1	0.56	1	0.54	1	0.55	1	0.52	1	0.51	1	0.54	1	0.53	1	0.54	1	0.55	1
17	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.48	1	0.61	1	0.55	1	0.53	1	0.52	1	0.49	1	0.51	1	0.50	1	0.50	1	0.46	1	0.50	1	0.48	1	0.46	1	0.49	1	0.49	1	0.48	1	0.50	1	0.37	1	0.32	1	0.48	1	0.36	1	0.44	1	0.48	1
	III	0.19	0	0.28	1	0.23	1	0.22	1	0.21	1	0.20	1	0.21	1	0.21	1	0.20	1	0.18	0	0.21	1	0.19	0	0.18	0	0.20	1	0.20	1	0.19	0	0.20	1	0.23	1	0.22	1	0.19	0	0.25	1	0.17	0	0.21	1
	IV	0.29	1	0.41	1	0.35	1	0.34	1	0.33	1	0.31	1	0.33	1	0.32	1	0.31	1	0.28	1	0.31	1	0.29	1	0.28	1	0.31	1	0.30	1	0.29	1	0.31	1	0.17	0	0.17	0	0.29	1	0.18	0	0.27	1	0.29	1
	Average	0.49	1	0.58	1	0.53	1	0.52	1	0.52	1	0.50	1	0.51	1	0.51	1	0.50	1	0.48	1	0.51	1	0.49	1	0.48	1	0.50	1	0.50	1	0.49	1	0.50	1	0.44	1	0.43	1	0.49	1	0.45	1	0.47	1	0.49	1

Note : CC = Residual Chlorine Concentration in mg/L
RQ = Water Quality Reliability
*) Refer to Table 4.11

Table F.2. Water Quality Reliability Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	State*																																												Average	
		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22			
		CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ
2	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.66	1	0.35	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.68	1	0.67	1	0.67	1	0.67	1	0.66	1	0.67	1	0.67	1	0.66	1	0.67	1	0.66	1	0.65	1
	III	0.32	1	0.25	1	0.31	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.33	1	0.32	1	0.32	1	0.32	1	0.32	1	0.33	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1
	IV	0.47	1	0.11	0	0.46	1	0.46	1	0.46	1	0.47	1	0.46	1	0.46	1	0.46	1	0.46	1	0.47	1	0.47	1	0.48	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.45	1
	Average	0.61	1	0.43	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.62	1	0.62	1	0.62	1	0.62	1	0.61	1	0.62	1	0.62	1	0.61	1	0.62	1	0.61	1	0.60	1
3	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.60	1	0.49	1	0.42	1	0.43	1	0.52	1	0.60	1	0.62	1	0.61	1	0.62	1	0.60	1	0.60	1	0.60	1	0.64	1	0.61	1	0.61	1	0.60	1	0.60	1	0.62	1	0.61	1	0.60	1	0.61	1	0.60	1	0.58	1
	III	0.27	1	0.19	0	0.17	0	0.35	1	0.22	1	0.27	1	0.28	1	0.29	1	0.28	1	0.27	1	0.27	1	0.27	1	0.30	1	0.28	1	0.28	1	0.28	1	0.27	1	0.29	1	0.28	1	0.27	1	0.28	1	0.27	1	0.27	1
	IV	0.40	1	0.30	1	0.24	1	0.26	1	0.33	1	0.40	1	0.42	1	0.42	1	0.42	1	0.40	1	0.40	1	0.40	1	0.44	1	0.42	1	0.41	1	0.41	1	0.40	1	0.42	1	0.42	1	0.40	1	0.41	1	0.41	1	0.39	1
	Average	0.57	1	0.50	1	0.46	1	0.51	1	0.52	1	0.57	1	0.58	1	0.58	1	0.58	1	0.57	1	0.57	1	0.57	1	0.60	1	0.58	1	0.58	1	0.57	1	0.57	1	0.58	1	0.58	1	0.57	1	0.58	1	0.57	1	0.56	1
4	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.57	1	0.55	1	0.51	1	0.47	1	0.41	1	0.56	1	0.59	1	0.59	1	0.58	1	0.56	1	0.56	1	0.57	1	0.61	1	0.58	1	0.57	1	0.57	1	0.56	1	0.59	1	0.58	1	0.57	1	0.57	1	0.57	1	0.56	1
	III	0.25	1	0.23	1	0.21	1	0.19	0	0.31	1	0.25	1	0.27	1	0.27	1	0.26	1	0.24	1	0.25	1	0.25	1	0.29	1	0.26	1	0.26	1	0.25	1	0.25	1	0.27	1	0.26	1	0.25	1	0.26	1	0.25	1	0.25	1
	IV	0.37	1	0.36	1	0.32	1	0.29	1	0.24	1	0.37	1	0.40	1	0.40	1	0.39	1	0.37	1	0.37	1	0.37	1	0.42	1	0.39	1	0.38	1	0.37	1	0.37	1	0.39	1	0.39	1	0.37	1	0.38	1	0.37	1	0.37	1
	Average	0.55	1	0.54	1	0.51	1	0.49	1	0.49	1	0.55	1	0.57	1	0.57	1	0.56	1	0.54	1	0.55	1	0.55	1	0.58	1	0.56	1	0.55	1	0.55	1	0.55	1	0.56	1	0.56	1	0.55	1	0.55	1	0.55	1	0.54	1
5	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.52	1	0.58	1	0.56	1	0.55	1	0.55	1	0.52	1	0.57	1	0.57	1	0.56	1	0.52	1	0.52	1	0.52	1	0.60	1	0.55	1	0.54	1	0.53	1	0.52	1	0.55	1	0.55	1	0.52	1	0.54	1	0.53	1	0.54	1
	III	0.22	1	0.26	1	0.24	1	0.25	1	0.24	1	0.22	1	0.25	1	0.24	1	0.24	1	0.21	1	0.22	1	0.22	1	0.27	1	0.23	1	0.23	1	0.22	1	0.22	1	0.24	1	0.23	1	0.22	1	0.23	1	0.22	1	0.23	1
	IV	0.34	1	0.39	1	0.37	1	0.36	1	0.36	1	0.33	1	0.38	1	0.37	1	0.37	1	0.33	1	0.33	1	0.34	1	0.40	1	0.36	1	0.35	1	0.34	1	0.33	1	0.36	1	0.36	1	0.34	1	0.35	1	0.34	1	0.35	1
	Average	0.52	1	0.56	1	0.54	1	0.54	1	0.54	1	0.52	1	0.55	1	0.55	1	0.54	1	0.52	1	0.52	1	0.52	1	0.57	1	0.54	1	0.53	1	0.52	1	0.52	1	0.54	1	0.54	1	0.52	1	0.53	1	0.52	1	0.53	1
6	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.45	1	0.43	1	0.43	1	0.45	1	0.47	1	0.43	1	0.48	1	0.48	1	0.47	1	0.45	1	0.48	1	0.43	1	0.54	1	0.47	1	0.46	1	0.45	1	0.44	1	0.49	1	0.48	1	0.45	1	0.48	1	0.46	1	0.46	1
	III	0.17	0	0.18	0	0.17	0	0.19	0	0.18	0	0.16	0	0.19	0	0.19	0	0.19	0	0.17	0	0.18	0	0.16	0	0.23	1	0.18	0	0.18	0	0.17	0	0.16	0	0.19	0	0.19	0	0.17	0	0.19	0	0.17	0	0.18	0
	IV	0.27	1	0.26	1	0.25	1	0.27	1	0.28	1	0.25	1	0.30	1	0.29	1	0.29	1	0.27	1	0.29	1	0.26	1	0.35	1	0.29	1	0.28	1	0.27	1	0.26	1	0.31	1	0.29	1	0.27	1	0.29	1	0.28	1	0.28	1
	Average	0.47	1	0.47	1	0.46	1	0.48	1	0.48	1	0.46	1	0.49	1	0.49	1	0.49	1	0.47	1	0.49	1	0.46	1	0.53	1	0.49	1	0.48	1	0.47	1	0.47	1	0.50	1	0.49	1	0.47	1	0.49	1	0.48	1	0.48	1
7	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.63	1	0.42	1	0.63	1	0.63	1	0.63	1	0.63	1	0.41	1	0.53	1	0.59	1	0.62	1	0.63	1	0.63	1	0.65	1	0.63	1	0.63	1	0.63	1	0.63	1	0.64	1	0.63	1	0.63	1	0.63	1	0.63	1	0.61	1
	III	0.29	1	0.20	1	0.30	1	0.30	1	0.30	1	0.29	1	0.14	0	0.23	1	0.27	1	0.29	1	0.29	1	0.29	1	0.31	1	0.30	1	0.30	1	0.29	1	0.29	1	0.30	1	0.30	1	0.29	1	0.30	1	0.29	1	0.28	1
	IV	0.43	1	0.18	0	0.43	1	0.44	1	0.43	1	0.43	1	0.24	1	0.34	1	0.39	1	0.42	1	0.43	1	0.43	1	0.45	1	0.44	1	0.43	1	0.43	1	0.43	1	0.44	1	0.44	1	0.43	1	0.43	1	0.43	1	0.41	1
	Average	0.59	1	0.45	1	0.59	1	0.59	1	0.59	1	0.59	1	0.45	1	0.53	1	0.56	1	0.58	1	0.59	1	0.59	1	0.60	1	0.59	1	0.59	1	0.59	1	0.59	1	0.60	1	0.59	1	0.59	1	0.59	1	0.59	1	0.57	1
8	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.57	1	0.51	1	0.61	1	0.61	1	0.60	1	0.57	1	0.51	1	0.45	1	0.47	1	0.57	1	0.57	1	0.57	1	0.62	1	0.58	1	0.57	1	0.57	1	0.57	1	0.59	1	0.58	1	0.57	1	0.57	1	0.57	1	0.56	1
	III	0.25	1	0.20	1	0.27	1	0.27	1	0.27	1	0.25	1	0.21	1	0.18	0	0.18	0	0.25	1	0.25	1	0.25	1	0.29	1	0.26	1	0.26	1	0.26	1	0.25	1	0.27	1	0.26	1	0.25	1	0.26	1	0.25	1	0.25	1
	IV	0.38	1	0.32	1	0.41	1	0.40	1	0.40	1	0.38	1	0.32	1	0.28	1	0.29	1	0.37	1	0.37	1	0.38	1	0.42	1	0.39	1	0.39	1	0.38	1	0.37	1	0.40	1	0.39	1	0.38	1	0.39	1	0.38	1	0.37	1
	Average	0.55	1	0.51	1	0.57	1	0.57	1	0.57	1	0.55	1	0.51	1	0.48	1	0.49	1	0.55	1	0.55	1	0.55	1	0.58	1	0.56	1	0.56	1	0.55	1	0.55	1	0.57	1	0.56	1	0.55	1	0.56	1	0.55	1	0.55	1
9	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.45	1	0.63	1	0.56	1	0.56	1	0.54	1	0.45	1	0.50	1	0.49	1	0.48	1	0.52	1	0.45	1	0.46	1	0.58	1	0.51	1	0.50	1	0.48	1	0.46	1	0.51	1	0.50	1	0.46	1	0.47	1	0.46	1	0.50	1
	III	0.17	0	0.29	1	0.25	1	0.23	1	0.22	1	0.18	0	0.22	1	0.20	1	0.19	0	0.22	1	0.17	0	0.17	0	0.25	1	0.21	1	0.20	1	0.19	0	0.18	0	0.20	1	0.20	1	0.18	0	0.21	1	0.18	0	0.21	1
	IV	0.27	1	0.42	1	0.37	1	0.36	1	0.35	1	0.27	1	0.31	1	0.30	1	0.29	1	0.33	1	0.28	1	0.27	1	0.38	1	0.33	1	0.31	1	0.30	1	0.28	1	0.32	1	0.30	1	0.28	1	0.28	1	0.28	1	0.31	1
	Average	0.47	1	0.59	1	0.55	1	0.54	1	0.53	1	0.48	1	0.51	1	0.50	1	0.49	1	0.52	1	0.48	1	0.48	1	0.55	1	0.51	1	0.50	1	0.49	1	0.48	1	0.51	1	0.50	1	0.48	1	0.49	1	0.48	1	0.50	1
10	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.45	1	0.57	1	0.45	1	0.46	1	0.49	1	0.49	1	0.50	1	0.49	1	0.48	1	0.45	1	0.41	1	0.48	1	0.55	1	0.47	1	0.46	1	0.46	1	0.46	1	0.50	1	0.49	1	0.45	1	0.48	1	0.46	1	0.48	1
	III	0.19	0	0.25	1	0.17	0	0.20	1	0.20	1	0.20	1	0.20	1	0.21	1	0.20	1	0.19	0	0.16	0	0.19	0	0.24	1	0.20	1	0.20	1	0.19	0	0.18	0	0.20	1	0.19	0	0.19	0	0.19	0	0.20	1	0.20	0
	IV	0.27	1	0.38	1	0.27	1	0.27	1	0.29	1	0.31	1	0.31	1	0.30	1	0.30	1	0.27	1	0.22	1	0.30	1	0.35	1	0.29	1	0.28	1	0.27	1	0.27	1	0.31	1	0.30	1	0.27	1	0.30	1	0.28	1	0.29	1
	Average	0.48	1	0.55	1	0.47	1	0.48	1	0.50	1	0.50	1	0.50	1	0.50	1	0.50	1	0.48	1	0.45	1	0.49	1	0.54	1	0.49	1	0.49	1	0.48	1	0.48	1	0.50	1	0.50	1	0.48	1	0.49	1	0.49	1	0.49	1

Table F.2. Water Quality Reliability Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	State*																																												Average	
		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22			
		CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ
11	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.67	1	0.69	1	0.67	1	0.67	1	0.67	1	0.67	1	0.67	1	0.67	1	0.67	1	0.67	1	0.67	1	0.67	1	0.38	1	0.66	1	0.66	1	0.67	1	0.67	1	0.66	1	0.66	1	0.67	1	0.66	1	0.67	1	0.66	1
	III	0.32	1	0.34	1	0.33	1	0.33	1	0.33	1	0.32	1	0.33	1	0.33	1	0.33	1	0.33	1	0.33	1	0.32	1	0.15	0	0.32	1	0.32	1	0.32	1	0.33	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1
	IV	0.47	1	0.48	1	0.48	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.15	0	0.46	1	0.47	1	0.47	1	0.47	1	0.46	1	0.46	1	0.47	1	0.47	1	0.47	1	0.46	1
	Average	0.62	1	0.63	1	0.62	1	0.62	1	0.62	1	0.62	1	0.62	1	0.62	1	0.62	1	0.62	1	0.62	1	0.62	1	0.42	1	0.61	1	0.61	1	0.62	1	0.62	1	0.61	1	0.61	1	0.62	1	0.61	1	0.62	1	0.61	1
12	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.63	1	0.66	1	0.64	1	0.65	1	0.65	1	0.63	1	0.64	1	0.64	1	0.64	1	0.64	1	0.63	1	0.63	1	0.48	1	0.42	1	0.58	1	0.62	1	0.63	1	0.63	1	0.63	1	0.63	1	0.63	1	0.63	1	0.62	1
	III	0.29	1	0.32	1	0.31	1	0.31	1	0.31	1	0.29	1	0.30	1	0.30	1	0.30	1	0.30	1	0.29	1	0.29	1	0.19	0	0.15	0	0.26	1	0.30	1	0.29	1	0.30	1	0.30	1	0.30	1	0.30	1	0.30	1	0.29	1
	IV	0.44	1	0.47	1	0.45	1	0.45	1	0.45	1	0.44	1	0.45	1	0.44	1	0.44	1	0.44	1	0.44	1	0.44	1	0.29	1	0.24	1	0.39	1	0.44	1	0.44	1	0.43	1	0.44	1	0.44	1	0.44	1	0.44	1	0.42	1
	Average	0.59	1	0.61	1	0.60	1	0.60	1	0.60	1	0.59	1	0.60	1	0.60	1	0.60	1	0.60	1	0.59	1	0.59	1	0.49	1	0.45	1	0.56	1	0.59	1	0.59	1	0.59	1	0.59	1	0.59	1	0.59	1	0.59	1	0.58	1
13	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.54	1	0.63	1	0.59	1	0.58	1	0.57	1	0.55	1	0.56	1	0.56	1	0.56	1	0.56	1	0.57	1	0.54	1	0.55	1	0.53	1	0.50	1	0.54	1	0.56	1	0.58	1	0.59	1	0.56	1	0.53	1	0.54	1	0.56	1
	III	0.22	1	0.30	1	0.27	1	0.25	1	0.25	1	0.24	1	0.25	1	0.24	1	0.24	1	0.24	1	0.24	1	0.22	1	0.24	1	0.22	1	0.20	1	0.23	1	0.24	1	0.26	1	0.26	1	0.24	1	0.23	1	0.23	1	0.24	1
	IV	0.35	1	0.44	1	0.39	1	0.38	1	0.38	1	0.36	1	0.37	1	0.37	1	0.36	1	0.36	1	0.37	1	0.35	1	0.36	1	0.34	1	0.32	1	0.36	1	0.37	1	0.38	1	0.39	1	0.37	1	0.35	1	0.35	1	0.37	1
	Average	0.53	1	0.59	1	0.56	1	0.55	1	0.55	1	0.54	1	0.55	1	0.54	1	0.54	1	0.54	1	0.55	1	0.53	1	0.54	1	0.52	1	0.51	1	0.53	1	0.54	1	0.56	1	0.56	1	0.54	1	0.53	1	0.53	1	0.54	1
14	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.36	1	0.60	1	0.52	1	0.50	1	0.48	1	0.39	1	0.45	1	0.40	1	0.39	1	0.37	1	0.46	1	0.37	1	0.51	1	0.37	1	0.37	1	0.38	1	0.46	1	0.45	1	0.43	1	0.37	1	0.44	1	0.39	1	0.43	1
	III	0.19	0	0.27	1	0.21	1	0.19	0	0.18	0	0.17	0	0.17	0	0.17	0	0.18	0	0.14	0	0.18	0	0.19	0	0.22	1	0.14	0	0.14	0	0.17	0	0.17	0	0.17	0	0.17	0	0.18	0	0.17	0	0.15	0	0.18	0
	IV	0.19	0	0.41	1	0.32	1	0.31	1	0.29	1	0.21	1	0.25	1	0.22	1	0.20	1	0.19	0	0.28	1	0.21	1	0.32	1	0.20	1	0.20	1	0.19	0	0.27	1	0.27	1	0.25	1	0.20	1	0.26	1	0.21	1	0.25	1
	Average	0.44	1	0.57	1	0.51	1	0.50	1	0.49	1	0.44	1	0.47	1	0.45	1	0.44	1	0.43	1	0.48	1	0.44	1	0.51	1	0.43	1	0.43	1	0.44	1	0.48	1	0.47	1	0.46	1	0.44	1	0.47	1	0.44	1	0.46	1
15	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.62	1	0.66	1	0.64	1	0.63	1	0.63	1	0.62	1	0.63	1	0.63	1	0.62	1	0.62	1	0.62	1	0.62	1	0.39	1	0.62	1	0.62	1	0.61	1	0.62	1	0.47	1	0.52	1	0.61	1	0.60	1	0.61	1	0.60	1
	III	0.29	1	0.32	1	0.30	1	0.30	1	0.29	1	0.29	1	0.29	1	0.29	1	0.29	1	0.29	1	0.29	1	0.29	1	0.15	0	0.29	1	0.29	1	0.28	1	0.29	1	0.19	0	0.22	1	0.28	1	0.28	1	0.28	1	0.28	1
	IV	0.42	1	0.47	1	0.44	1	0.44	1	0.43	1	0.42	1	0.43	1	0.43	1	0.42	1	0.42	1	0.42	1	0.42	1	0.22	1	0.43	1	0.42	1	0.42	1	0.42	1	0.29	1	0.33	1	0.42	1	0.41	1	0.42	1	0.41	1
	Average	0.58	1	0.61	1	0.60	1	0.59	1	0.59	1	0.58	1	0.59	1	0.59	1	0.58	1	0.58	1	0.58	1	0.58	1	0.44	1	0.59	1	0.58	1	0.58	1	0.58	1	0.49	1	0.52	1	0.58	1	0.57	1	0.58	1	0.57	1
16	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.59	1	0.65	1	0.62	1	0.60	1	0.61	1	0.59	1	0.60	1	0.60	1	0.60	1	0.59	1	0.58	1	0.59	1	0.43	1	0.59	1	0.59	1	0.57	1	0.58	1	0.54	1	0.54	1	0.59	1	0.56	1	0.58	1	0.58	1
	III	0.26	1	0.31	1	0.28	1	0.28	1	0.27	1	0.26	1	0.27	1	0.27	1	0.27	1	0.27	1	0.26	1	0.26	1	0.17	0	0.27	1	0.27	1	0.26	1	0.26	1	0.24	1	0.22	1	0.26	1	0.24	1	0.26	1	0.26	1
	IV	0.39	1	0.45	1	0.42	1	0.41	1	0.41	1	0.39	1	0.41	1	0.40	1	0.39	1	0.39	1	0.38	1	0.39	1	0.25	1	0.40	1	0.40	1	0.37	1	0.38	1	0.35	1	0.35	1	0.39	1	0.37	1	0.39	1	0.39	1
	Average	0.56	1	0.60	1	0.58	1	0.57	1	0.57	1	0.56	1	0.57	1	0.57	1	0.57	1	0.56	1	0.56	1	0.56	1	0.46	1	0.57	1	0.57	1	0.55	1	0.56	1	0.53	1	0.53	1	0.56	1	0.54	1	0.56	1	0.56	1
17	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.51	1	0.62	1	0.57	1	0.55	1	0.55	1	0.52	1	0.53	1	0.52	1	0.53	1	0.49	1	0.52	1	0.51	1	0.48	1	0.52	1	0.52	1	0.50	1	0.52	1	0.39	1	0.36	1	0.51	1	0.39	1	0.48	1	0.50	1
	III	0.20	1	0.29	1	0.24	1	0.24	1	0.23	1	0.21	1	0.22	1	0.22	1	0.21	1	0.20	1	0.21	1	0.21	1	0.20	1	0.21	1	0.21	1	0.21	1	0.22	1	0.15	0	0.13	0	0.20	1	0.15	0	0.19	0	0.21	1
	IV	0.32	1	0.43	1	0.37	1	0.36	1	0.35	1	0.33	1	0.34	1	0.34	1	0.33	1	0.30	1	0.33	1	0.32	1	0.30	1	0.33	1	0.33	1	0.31	1	0.33	1	0.21	1	0.19	0	0.32	1	0.22	1	0.29	1	0.32	1
	Average	0.51	1	0.59	1	0.55	1	0.54	1	0.53	1	0.52	1	0.52	1	0.52	1	0.52	1	0.50	1	0.52	1	0.51	1	0.50	1	0.52	1	0.52	1	0.51	1	0.52	1	0.44	1	0.42	1	0.51	1	0.44	1	0.49	1	0.51	1

Note : CC = Residual Chlorine Concentration in mg/L
RQ = Water Quality Reliability
*) Refer to Table 4.11

Table F.3. Water Quality Reliability Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	State*																																										Average	
		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22			
		CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ
2	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.65	1	0.52	1	0.64	1	0.64	1	0.65	1	0.65	1	0.65	1	0.65	1	0.65	1	0.65	1	0.65	1	0.65	1	0.67	1	0.66	1	0.66	1	0.65	1	0.65	1	0.66	1	0.66	1	0.65	1	0.66	1	0.65	1	0.65	1
	III	0.31	1	0.19	0	0.30	1	0.30	1	0.31	1	0.31	1	0.31	1	0.31	1	0.31	1	0.31	1	0.31	1	0.31	1	0.32	1	0.32	1	0.31	1	0.31	1	0.31	1	0.32	1	0.32	1	0.31	1	0.31	1	0.31	1	0.31	1
	IV	0.45	1	0.14	0	0.44	1	0.44	1	0.45	1	0.45	1	0.45	1	0.45	1	0.45	1	0.45	1	0.45	1	0.45	1	0.47	1	0.46	1	0.46	1	0.45	1	0.45	1	0.46	1	0.46	1	0.45	1	0.46	1	0.45	1	0.44	1
	Average	0.60	1	0.46	1	0.60	1	0.60	1	0.60	1	0.60	1	0.60	1	0.60	1	0.60	1	0.60	1	0.60	1	0.60	1	0.62	1	0.61	1	0.61	1	0.60	1	0.60	1	0.61	1	0.61	1	0.60	1	0.61	1	0.60	1	0.60	1
3	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.56	1	0.42	1	0.35	1	0.37	1	0.47	1	0.56	1	0.58	1	0.59	1	0.58	1	0.56	1	0.56	1	0.56	1	0.62	1	0.59	1	0.57	1	0.57	1	0.56	1	0.59	1	0.58	1	0.56	1	0.57	1	0.57	1	0.54	1
	III	0.25	1	0.18	0	0.25	1	0.30	1	0.18	0	0.25	1	0.26	1	0.26	1	0.26	1	0.24	1	0.24	1	0.25	1	0.29	1	0.26	1	0.25	1	0.25	1	0.24	1	0.26	1	0.26	1	0.25	1	0.25	1	0.25	1	0.25	1
	IV	0.37	1	0.24	1	0.13	0	0.14	0	0.29	1	0.37	1	0.39	1	0.39	1	0.39	1	0.36	1	0.36	1	0.37	1	0.42	1	0.39	1	0.38	1	0.37	1	0.37	1	0.39	1	0.39	1	0.38	1	0.38	1	0.37	1	0.35	1
	Average	0.55	1	0.46	1	0.43	1	0.45	1	0.49	1	0.55	1	0.56	1	0.56	1	0.56	1	0.54	1	0.54	1	0.55	1	0.58	1	0.56	1	0.55	1	0.55	1	0.54	1	0.56	1	0.56	1	0.55	1	0.55	1	0.55	1	0.53	1
4	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.52	1	0.50	1	0.45	1	0.40	1	0.34	1	0.52	1	0.55	1	0.55	1	0.54	1	0.51	1	0.51	1	0.52	1	0.58	1	0.54	1	0.53	1	0.52	1	0.51	1	0.55	1	0.54	1	0.52	1	0.53	1	0.52	1	0.51	1
	III	0.21	1	0.19	0	0.18	0	0.16	0	0.27	1	0.21	1	0.23	1	0.23	1	0.23	1	0.20	1	0.21	1	0.21	1	0.26	1	0.22	1	0.23	1	0.21	1	0.21	1	0.23	1	0.22	1	0.22	1	0.22	1	0.21	1	0.22	1
	IV	0.33	1	0.31	1	0.28	1	0.23	1	0.13	0	0.33	1	0.36	1	0.36	1	0.34	1	0.32	1	0.33	1	0.33	1	0.39	1	0.34	1	0.34	1	0.33	1	0.33	1	0.36	1	0.35	1	0.33	1	0.34	1	0.33	1	0.32	1
	Average	0.52	1	0.50	1	0.48	1	0.45	1	0.44	1	0.52	1	0.54	1	0.54	1	0.53	1	0.51	1	0.51	1	0.52	1	0.56	1	0.53	1	0.53	1	0.52	1	0.51	1	0.54	1	0.53	1	0.52	1	0.52	1	0.52	1	0.51	1
5	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.47	1	0.55	1	0.51	1	0.50	1	0.51	1	0.46	1	0.52	1	0.52	1	0.51	1	0.45	1	0.46	1	0.47	1	0.55	1	0.49	1	0.49	1	0.47	1	0.46	1	0.50	1	0.49	1	0.47	1	0.48	1	0.47	1	0.49	1
	III	0.18	0	0.23	1	0.21	1	0.22	1	0.21	1	0.18	0	0.22	1	0.21	1	0.21	1	0.18	0	0.18	0	0.18	0	0.24	1	0.20	1	0.19	0	0.18	0	0.18	0	0.20	1	0.20	1	0.18	0	0.19	0	0.18	0	0.20	0
	IV	0.28	1	0.35	1	0.32	1	0.32	1	0.32	1	0.28	1	0.34	1	0.33	1	0.32	1	0.27	1	0.28	1	0.28	1	0.36	1	0.30	1	0.30	1	0.29	1	0.28	1	0.31	1	0.31	1	0.28	1	0.30	1	0.29	1	0.31	1
	Average	0.48	1	0.53	1	0.51	1	0.51	1	0.51	1	0.48	1	0.52	1	0.52	1	0.51	1	0.48	1	0.48	1	0.48	1	0.54	1	0.50	1	0.50	1	0.49	1	0.48	1	0.50	1	0.50	1	0.48	1	0.49	1	0.49	1	0.50	1
6	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.37	1	0.36	1	0.38	1	0.39	1	0.40	1	0.36	1	0.41	1	0.41	1	0.41	1	0.37	1	0.40	1	0.36	1	0.48	1	0.39	1	0.39	1	0.38	1	0.36	1	0.42	1	0.40	1	0.37	1	0.41	1	0.38	1	0.39	1
	III	0.23	1	0.17	0	0.14	0	0.15	0	0.14	0	0.22	1	0.15	0	0.14	0	0.15	0	0.26	1	0.14	0	0.25	1	0.19	0	0.14	0	0.14	0	0.20	1	0.25	1	0.16	0	0.14	0	0.24	1	0.14	0	0.15	0	0.18	0
	IV	0.20	1	0.18	0	0.20	1	0.22	1	0.22	1	0.19	0	0.24	1	0.23	1	0.23	1	0.20	1	0.23	1	0.20	1	0.30	1	0.23	1	0.22	1	0.21	1	0.20	1	0.24	1	0.23	1	0.21	1	0.23	1	0.22	1	0.22	1
	Average	0.45	1	0.43	1	0.43	1	0.44	1	0.44	1	0.44	1	0.45	1	0.45	1	0.45	1	0.46	1	0.44	1	0.45	1	0.49	1	0.44	1	0.44	1	0.45	1	0.45	1	0.46	1	0.44	1	0.46	1	0.45	1	0.44	1	0.45	1
7	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.59	1	0.39	1	0.60	1	0.61	1	0.60	1	0.59	1	0.33	1	0.48	1	0.55	1	0.59	1	0.59	1	0.59	1	0.63	1	0.61	1	0.60	1	0.60	1	0.59	1	0.61	1	0.61	1	0.59	1	0.60	1	0.60	1	0.57	1
	III	0.27	1	0.25	1	0.28	1	0.28	1	0.28	1	0.27	1	0.23	1	0.19	0	0.24	1	0.27	1	0.27	1	0.27	1	0.30	1	0.28	1	0.27	1	0.27	1	0.27	1	0.28	1	0.28	1	0.27	1	0.27	1	0.27	1	0.27	1
	IV	0.40	1	0.12	0	0.41	1	0.41	1	0.41	1	0.39	1	0.11	0	0.30	1	0.35	1	0.39	1	0.39	1	0.40	1	0.43	1	0.41	1	0.40	1	0.40	1	0.39	1	0.41	1	0.41	1	0.40	1	0.40	1	0.40	1	0.37	1
	Average	0.57	1	0.44	1	0.57	1	0.58	1	0.57	1	0.56	1	0.42	1	0.49	1	0.54	1	0.56	1	0.56	1	0.57	1	0.59	1	0.58	1	0.57	1	0.57	1	0.56	1	0.58	1	0.58	1	0.57	1	0.57	1	0.57	1	0.55	1
8	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.53	1	0.44	1	0.57	1	0.56	1	0.56	1	0.52	1	0.44	1	0.38	1	0.40	1	0.52	1	0.52	1	0.53	1	0.58	1	0.55	1	0.54	1	0.53	1	0.52	1	0.55	1	0.55	1	0.53	1	0.54	1	0.53	1	0.52	1
	III	0.22	1	0.16	0	0.25	1	0.24	1	0.24	1	0.22	1	0.16	0	0.21	1	0.30	1	0.22	1	0.22	1	0.22	1	0.26	1	0.23	1	0.23	1	0.23	1	0.22	1	0.23	1	0.23	1	0.22	1	0.23	1	0.22	1	0.23	1
	IV	0.34	1	0.27	1	0.38	1	0.37	1	0.37	1	0.33	1	0.26	1	0.22	1	0.24	1	0.33	1	0.33	1	0.34	1	0.39	1	0.35	1	0.35	1	0.34	1	0.33	1	0.36	1	0.35	1	0.34	1	0.35	1	0.34	1	0.33	1
	Average	0.52	1	0.47	1	0.55	1	0.54	1	0.54	1	0.52	1	0.47	1	0.45	1	0.49	1	0.52	1	0.52	1	0.52	1	0.56	1	0.53	1	0.53	1	0.53	1	0.52	1	0.54	1	0.53	1	0.52	1	0.53	1	0.52	1	0.52	1
9	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.38	1	0.60	1	0.52	1	0.50	1	0.49	1	0.38	1	0.46	1	0.42	1	0.41	1	0.46	1	0.38	1	0.38	1	0.53	1	0.45	1	0.43	1	0.41	1	0.38	1	0.44	1	0.42	1	0.39	1	0.43	1	0.39	1	0.44	1
	III	0.22	1	0.26	1	0.21	1	0.20	1	0.19	0	0.18	0	0.18	0	0.19	0	0.20	1	0.18	0	0.15	0	0.22	1	0.22	1	0.17	0	0.16	0	0.15	0	0.15	0	0.17	0	0.16	0	0.16	0	0.16	0	0.19	0	0.19	0
	IV	0.21	1	0.40	1	0.32	1	0.31	1	0.30	1	0.21	1	0.27	1	0.24	1	0.24	1	0.28	1	0.21	1	0.21	1	0.34	1	0.27	1	0.25	1	0.24	1	0.21	1	0.26	1	0.25	1	0.22	1	0.24	1	0.22	1	0.26	1
	Average	0.45	1	0.57	1	0.51	1	0.50	1	0.50	1	0.44	1	0.48	1	0.46	1	0.46	1	0.48	1	0.44	1	0.45	1	0.52	1	0.47	1	0.46	1	0.45	1	0.44	1	0.47	1	0.46	1	0.44	1	0.46	1	0.45	1	0.47	1
10	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.40	1	0.53	1	0.38	1	0.41	1	0.44	1	0.42	1	0.45	1	0.43	1	0.43	1	0.38	1	0.35	1	0.41	1	0.49	1	0.41	1	0.41	1	0.40	1	0.39	1	0.44	1	0.42	1	0.40	1	0.42	1	0.39	1	0.42	1
	III	0.14	0	0.22	1	0.17	0	0.16	0	0.18	0	0.15	0	0.17	0	0.16	0	0.16	0	0.15	0	0.21	1	0.15	0	0.20	1	0.16	0	0.15	0	0.14	0	0.14	0	0.18	0	0.18	0	0.14	0	0.17	0	0.15	0	0.17	0
	IV	0.21	1	0.34	1	0.20	1	0.21	1	0.25	1	0.24	1	0.25	1	0.25	1	0.24	1	0.21	1	0.17	0	0.24	1	0.31	1	0.23	1	0.23	1	0.22	1	0.22	1	0.26	1	0.24	1	0.21	1	0.24	1	0.21	1	0.24	1
	Average	0.44	1	0.52	1	0.44	1	0.45	1	0.47	1	0.45	1	0.47	1	0.46	1	0.46	1	0.44	1	0.43	1	0.45	1	0.50	1	0.45	1	0.45	1	0.44	1	0.44	1	0.47	1	0.46	1	0.44	1	0.46	1	0.44	1	0.45	1

Table F.3. Water Quality Reliability Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	State*																																												Average	
		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22			
		CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ
11	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.66	1	0.67	1	0.67	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.36	1	0.64	1	0.65	1	0.66	1	0.66	1	0.64	1	0.64	1	0.66	1	0.65	1	0.66	1	0.64	1
	III	0.32	1	0.33	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.32	1	0.22	1	0.31	1	0.31	1	0.31	1	0.32	1	0.30	1	0.31	1	0.32	1	0.31	1	0.31	1	0.31	1
	IV	0.46	1	0.48	1	0.47	1	0.47	1	0.46	1	0.46	1	0.46	1	0.46	1	0.46	1	0.46	1	0.46	1	0.46	1	0.09	0	0.45	1	0.45	1	0.45	1	0.46	1	0.44	1	0.45	1	0.46	1	0.45	1	0.46	1	0.44	1
	Average	0.61	1	0.62	1	0.62	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.42	1	0.60	1	0.60	1	0.61	1	0.61	1	0.60	1	0.60	1	0.61	1	0.60	1	0.61	1	0.60	1
12	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.61	1	0.66	1	0.63	1	0.63	1	0.63	1	0.61	1	0.62	1	0.62	1	0.62	1	0.62	1	0.61	1	0.61	1	0.40	1	0.34	1	0.55	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.59	1
	III	0.28	1	0.31	1	0.30	1	0.30	1	0.28	1	0.28	1	0.29	1	0.28	1	0.29	1	0.29	1	0.28	1	0.28	1	0.14	0	0.15	0	0.23	1	0.27	1	0.28	1	0.28	1	0.28	1	0.28	1	0.27	1	0.27	1	0.27	1
	IV	0.41	1	0.46	1	0.44	1	0.43	1	0.43	1	0.41	1	0.43	1	0.42	1	0.41	1	0.41	1	0.41	1	0.41	1	0.23	1	0.17	0	0.36	1	0.41	1	0.41	1	0.41	1	0.42	1	0.41	1	0.41	1	0.41	1	0.40	1
	Average	0.58	1	0.61	1	0.59	1	0.59	1	0.59	1	0.58	1	0.59	1	0.58	1	0.58	1	0.58	1	0.58	1	0.58	1	0.44	1	0.42	1	0.54	1	0.57	1	0.58	1	0.58	1	0.58	1	0.58	1	0.57	1	0.57	1	0.56	1
13	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.48	1	0.61	1	0.55	1	0.53	1	0.53	1	0.50	1	0.51	1	0.51	1	0.50	1	0.51	1	0.51	1	0.48	1	0.51	1	0.46	1	0.44	1	0.49	1	0.51	1	0.53	1	0.54	1	0.52	1	0.47	1	0.48	1	0.51	1
	III	0.19	0	0.28	1	0.23	1	0.23	1	0.22	1	0.20	1	0.21	1	0.21	1	0.20	1	0.21	1	0.21	1	0.21	1	0.21	1	0.18	0	0.20	1	0.20	1	0.21	1	0.23	1	0.23	1	0.21	1	0.19	0	0.19	0	0.21	1
	IV	0.30	1	0.42	1	0.36	1	0.35	1	0.33	1	0.31	1	0.33	1	0.32	1	0.31	1	0.32	1	0.32	1	0.30	1	0.32	1	0.28	1	0.26	1	0.31	1	0.32	1	0.34	1	0.35	1	0.32	1	0.29	1	0.30	1	0.32	1
	Average	0.49	1	0.58	1	0.54	1	0.53	1	0.52	1	0.50	1	0.51	1	0.51	1	0.50	1	0.51	1	0.51	1	0.50	1	0.51	1	0.48	1	0.48	1	0.50	1	0.51	1	0.53	1	0.53	1	0.51	1	0.49	1	0.49	1	0.51	1
14	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.28	1	0.57	1	0.44	1	0.43	1	0.41	1	0.36	1	0.39	1	0.37	1	0.35	1	0.31	1	0.38	1	0.29	1	0.45	1	0.29	1	0.29	1	0.34	1	0.38	1	0.38	1	0.35	1	0.33	1	0.37	1	0.32	1	0.37	1
	III	0.18	0	0.24	1	0.17	0	0.16	0	0.15	0	0.13	0	0.14	0	0.13	0	0.14	0	0.20	1	0.14	0	0.19	0	0.17	0	0.19	0	0.19	0	0.13	0	0.13	0	0.15	0	0.14	0	0.19	0	0.14	0	0.20	1	0.16	0
	IV	0.10	0	0.38	1	0.27	1	0.25	1	0.23	1	0.18	0	0.20	1	0.18	0	0.14	0	0.09	0	0.22	1	0.12	0	0.28	1	0.12	0	0.12	0	0.14	0	0.21	1	0.20	1	0.19	0	0.12	0	0.19	0	0.11	0	0.18	0
	Average	0.39	1	0.55	1	0.47	1	0.46	1	0.45	1	0.42	1	0.43	1	0.42	1	0.41	1	0.40	1	0.44	1	0.40	1	0.48	1	0.40	1	0.40	1	0.40	1	0.43	1	0.43	1	0.42	1	0.41	1	0.43	1	0.41	1	0.43	1
15	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.59	1	0.65	1	0.61	1	0.61	1	0.61	1	0.59	1	0.60	1	0.60	1	0.59	1	0.59	1	0.59	1	0.59	1	0.30	1	0.60	1	0.59	1	0.58	1	0.59	1	0.42	1	0.47	1	0.59	1	0.57	1	0.59	1	0.57	1
	III	0.27	1	0.31	1	0.28	1	0.28	1	0.28	1	0.27	1	0.28	1	0.27	1	0.27	1	0.27	1	0.27	1	0.27	1	0.17	0	0.27	1	0.27	1	0.26	1	0.27	1	0.15	0	0.19	0	0.26	1	0.25	1	0.26	1	0.26	1
	IV	0.40	1	0.45	1	0.42	1	0.41	1	0.41	1	0.40	1	0.41	1	0.41	1	0.40	1	0.40	1	0.40	1	0.40	1	0.14	0	0.40	1	0.40	1	0.39	1	0.40	1	0.24	1	0.29	1	0.39	1	0.38	1	0.39	1	0.38	1
	Average	0.57	1	0.60	1	0.58	1	0.58	1	0.58	1	0.57	1	0.57	1	0.57	1	0.57	1	0.57	1	0.57	1	0.57	1	0.40	1	0.57	1	0.57	1	0.56	1	0.57	1	0.45	1	0.49	1	0.56	1	0.55	1	0.56	1	0.55	1
16	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.54	1	0.63	1	0.59	1	0.57	1	0.58	1	0.55	1	0.57	1	0.56	1	0.55	1	0.54	1	0.53	1	0.54	1	0.35	1	0.56	1	0.56	1	0.52	1	0.54	1	0.49	1	0.49	1	0.54	1	0.51	1	0.54	1	0.54	1
	III	0.23	1	0.29	1	0.26	1	0.26	1	0.25	1	0.23	1	0.25	1	0.24	1	0.24	1	0.23	1	0.23	1	0.23	1	0.15	0	0.24	1	0.24	1	0.22	1	0.23	1	0.20	1	0.19	0	0.23	1	0.21	1	0.23	1	0.23	1
	IV	0.35	1	0.44	1	0.39	1	0.38	1	0.38	1	0.36	1	0.37	1	0.37	1	0.36	1	0.36	1	0.34	1	0.36	1	0.19	0	0.37	1	0.36	1	0.33	1	0.35	1	0.30	1	0.30	1	0.35	1	0.32	1	0.35	1	0.35	1
	Average	0.53	1	0.59	1	0.56	1	0.55	1	0.55	1	0.54	1	0.55	1	0.54	1	0.54	1	0.53	1	0.53	1	0.53	1	0.42	1	0.54	1	0.54	1	0.52	1	0.53	1	0.50	1	0.50	1	0.53	1	0.51	1	0.53	1	0.53	1
17	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.44	1	0.60	1	0.51	1	0.50	1	0.49	1	0.46	1	0.48	1	0.47	1	0.46	1	0.43	1	0.46	1	0.45	1	0.41	1	0.46	1	0.46	1	0.44	1	0.47	1	0.33	1	0.29	1	0.44	1	0.31	1	0.41	1	0.44	1
	III	0.17	0	0.26	1	0.21	1	0.20	1	0.20	1	0.18	0	0.19	0	0.19	0	0.18	0	0.16	0	0.19	0	0.17	0	0.15	0	0.18	0	0.17	0	0.17	0	0.18	0	0.19	0	0.19	0	0.17	0	0.20	1	0.15	0	0.18	0
	IV	0.27	1	0.40	1	0.33	1	0.31	1	0.30	1	0.28	1	0.30	1	0.29	1	0.28	1	0.25	1	0.28	1	0.27	1	0.25	1	0.28	1	0.28	1	0.25	1	0.28	1	0.14	0	0.11	0	0.27	1	0.15	0	0.24	1	0.26	1
	Average	0.47	1	0.57	1	0.51	1	0.50	1	0.50	1	0.48	1	0.49	1	0.49	1	0.48	1	0.46	1	0.48	1	0.47	1	0.45	1	0.48	1	0.48	1	0.47	1	0.48	1	0.42	1	0.40	1	0.47	1	0.42	1	0.45	1	0.47	1

Note : CC = Residual Chlorine Concentration in mg/L
RQ = Water Quality Reliability
*) Refer to Table 4.11

Table F.4. Water Quality Reliability Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																																												Average	
		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22			
		CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ
2	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.79	1	0.38	1	0.77	1	0.78	1	0.78	1	0.79	1	0.78	1	0.78	1	0.79	1	0.79	1	0.79	1	0.79	1	0.80	1	0.79	1	0.79	1	0.79	1	0.79	1	0.79	1	0.79	1	0.79	1	0.79	1	0.79	1	0.77	1
	III	0.58	1	0.30	1	0.56	1	0.56	1	0.57	1	0.58	1	0.57	1	0.58	1	0.58	1	0.58	1	0.58	1	0.58	1	0.59	1	0.58	1	0.58	1	0.58	1	0.58	1	0.59	1	0.58	1	0.58	1	0.58	1	0.58	1	0.57	1
	IV	0.72	1	0.19	0	0.70	1	0.71	1	0.71	1	0.71	1	0.71	1	0.71	1	0.71	1	0.71	1	0.71	1	0.72	1	0.74	1	0.72	1	0.72	1	0.72	1	0.71	1	0.72	1	0.72	1	0.72	1	0.72	1	0.72	1	0.69	1
	Average	0.77	1	0.47	1	0.76	1	0.76	1	0.77	1	0.77	1	0.77	1	0.77	1	0.77	1	0.77	1	0.77	1	0.77	1	0.78	1	0.77	1	0.77	1	0.77	1	0.77	1	0.78	1	0.77	1	0.77	1	0.77	1	0.77	1	0.76	1
3	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.71	1	0.58	1	0.48	1	0.50	1	0.60	1	0.71	1	0.73	1	0.73	1	0.72	1	0.70	1	0.71	1	0.71	1	0.75	1	0.73	1	0.72	1	0.71	1	0.71	1	0.73	1	0.73	1	0.71	1	0.72	1	0.71	1	0.69	1
	III	0.49	1	0.35	1	0.28	1	0.41	1	0.38	1	0.49	1	0.51	1	0.51	1	0.50	1	0.48	1	0.48	1	0.49	1	0.54	1	0.50	1	0.50	1	0.49	1	0.49	1	0.51	1	0.50	1	0.49	1	0.50	1	0.49	1	0.47	1
	IV	0.61	1	0.46	1	0.36	1	0.38	1	0.50	1	0.61	1	0.64	1	0.64	1	0.63	1	0.61	1	0.61	1	0.61	1	0.67	1	0.64	1	0.63	1	0.62	1	0.61	1	0.64	1	0.64	1	0.62	1	0.63	1	0.62	1	0.59	1
	Average	0.70	1	0.60	1	0.53	1	0.57	1	0.62	1	0.70	1	0.72	1	0.72	1	0.71	1	0.70	1	0.70	1	0.70	1	0.74	1	0.72	1	0.71	1	0.71	1	0.70	1	0.72	1	0.72	1	0.71	1	0.71	1	0.71	1	0.69	1
4	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.66	1	0.66	1	0.59	1	0.55	1	0.48	1	0.66	1	0.69	1	0.69	1	0.68	1	0.65	1	0.66	1	0.66	1	0.72	1	0.69	1	0.68	1	0.67	1	0.66	1	0.69	1	0.69	1	0.66	1	0.67	1	0.67	1	0.66	1
	III	0.44	1	0.42	1	0.37	1	0.33	1	0.38	1	0.44	1	0.48	1	0.47	1	0.46	1	0.43	1	0.43	1	0.44	1	0.51	1	0.46	1	0.45	1	0.44	1	0.44	1	0.47	1	0.46	1	0.44	1	0.45	1	0.44	1	0.44	1
	IV	0.56	1	0.56	1	0.50	1	0.43	1	0.36	1	0.56	1	0.60	1	0.60	1	0.59	1	0.55	1	0.56	1	0.56	1	0.65	1	0.59	1	0.58	1	0.57	1	0.56	1	0.59	1	0.59	1	0.57	1	0.58	1	0.57	1	0.56	1
	Average	0.67	1	0.66	1	0.62	1	0.58	1	0.56	1	0.67	1	0.69	1	0.69	1	0.68	1	0.66	1	0.66	1	0.67	1	0.72	1	0.69	1	0.68	1	0.67	1	0.67	1	0.69	1	0.69	1	0.67	1	0.68	1	0.67	1	0.66	1
5	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.61	1	0.70	1	0.65	1	0.65	1	0.66	1	0.61	1	0.68	1	0.66	1	0.65	1	0.60	1	0.60	1	0.62	1	0.70	1	0.64	1	0.63	1	0.63	1	0.61	1	0.65	1	0.64	1	0.62	1	0.64	1	0.62	1	0.64	1
	III	0.39	1	0.47	1	0.43	1	0.43	1	0.42	1	0.38	1	0.45	1	0.44	1	0.43	1	0.38	1	0.38	1	0.39	1	0.48	1	0.42	1	0.41	1	0.40	1	0.38	1	0.43	1	0.42	1	0.39	1	0.41	1	0.39	1	0.41	1
	IV	0.51	1	0.61	1	0.56	1	0.56	1	0.55	1	0.50	1	0.58	1	0.56	1	0.56	1	0.49	1	0.50	1	0.50	1	0.61	1	0.54	1	0.53	1	0.52	1	0.50	1	0.55	1	0.54	1	0.51	1	0.53	1	0.51	1	0.54	1
	Average	0.63	1	0.70	1	0.66	1	0.66	1	0.66	1	0.62	1	0.68	1	0.67	1	0.66	1	0.62	1	0.62	1	0.63	1	0.70	1	0.65	1	0.64	1	0.64	1	0.62	1	0.66	1	0.65	1	0.63	1	0.65	1	0.63	1	0.65	1
6	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.52	1	0.52	1	0.50	1	0.52	1	0.55	1	0.51	1	0.56	1	0.56	1	0.55	1	0.52	1	0.55	1	0.50	1	0.64	1	0.54	1	0.54	1	0.52	1	0.50	1	0.57	1	0.57	1	0.52	1	0.56	1	0.53	1	0.54	1
	III	0.29	1	0.30	1	0.29	1	0.31	1	0.31	1	0.28	1	0.33	1	0.33	1	0.32	1	0.30	1	0.32	1	0.28	1	0.40	1	0.32	1	0.31	1	0.30	1	0.28	1	0.34	1	0.33	1	0.30	1	0.33	1	0.30	1	0.31	1
	IV	0.40	1	0.40	1	0.38	1	0.40	1	0.42	1	0.38	1	0.45	1	0.44	1	0.44	1	0.40	1	0.43	1	0.38	1	0.52	1	0.43	1	0.42	1	0.41	1	0.38	1	0.46	1	0.45	1	0.40	1	0.44	1	0.42	1	0.42	1
	Average	0.55	1	0.56	1	0.54	1	0.56	1	0.57	1	0.54	1	0.59	1	0.58	1	0.58	1	0.56	1	0.58	1	0.54	1	0.64	1	0.57	1	0.57	1	0.56	1	0.54	1	0.59	1	0.59	1	0.56	1	0.58	1	0.56	1	0.57	1
7	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.74	1	0.46	1	0.74	1	0.75	1	0.75	1	0.74	1	0.47	1	0.62	1	0.69	1	0.73	1	0.74	1	0.74	1	0.77	1	0.75	1	0.74	1	0.74	1	0.74	1	0.75	1	0.75	1	0.74	1	0.74	1	0.74	1	0.71	1
	III	0.52	1	0.25	1	0.53	1	0.53	1	0.53	1	0.52	1	0.25	1	0.40	1	0.47	1	0.51	1	0.51	1	0.52	1	0.56	1	0.53	1	0.52	1	0.52	1	0.51	1	0.53	1	0.53	1	0.51	1	0.52	1	0.52	1	0.49	1
	IV	0.64	1	0.26	1	0.66	1	0.67	1	0.66	1	0.65	1	0.35	1	0.52	1	0.60	1	0.65	1	0.65	1	0.64	1	0.69	1	0.67	1	0.66	1	0.65	1	0.65	1	0.67	1	0.67	1	0.65	1	0.66	1	0.65	1	0.62	1
	Average	0.73	1	0.49	1	0.73	1	0.74	1	0.74	1	0.73	1	0.52	1	0.64	1	0.69	1	0.72	1	0.73	1	0.73	1	0.76	1	0.74	1	0.73	1	0.73	1	0.73	1	0.74	1	0.74	1	0.73	1	0.73	1	0.73	1	0.70	1
8	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.68	1	0.60	1	0.71	1	0.71	1	0.71	1	0.68	1	0.59	1	0.53	1	0.55	1	0.67	1	0.67	1	0.68	1	0.74	1	0.70	1	0.69	1	0.68	1	0.68	1	0.70	1	0.70	1	0.68	1	0.69	1	0.68	1	0.67	1
	III	0.44	1	0.37	1	0.49	1	0.49	1	0.48	1	0.44	1	0.36	1	0.31	1	0.33	1	0.44	1	0.44	1	0.44	1	0.51	1	0.47	1	0.46	1	0.46	1	0.44	1	0.47	1	0.47	1	0.45	1	0.46	1	0.46	1	0.44	1
	IV	0.57	1	0.50	1	0.62	1	0.62	1	0.61	1	0.58	1	0.49	1	0.41	1	0.44	1	0.57	1	0.57	1	0.57	1	0.65	1	0.59	1	0.59	1	0.58	1	0.57	1	0.60	1	0.59	1	0.57	1	0.59	1	0.58	1	0.57	1
	Average	0.67	1	0.62	1	0.71	1	0.71	1	0.70	1	0.68	1	0.61	1	0.56	1	0.58	1	0.67	1	0.67	1	0.67	1	0.73	1	0.69	1	0.69	1	0.68	1	0.67	1	0.69	1	0.69	1	0.68	1	0.69	1	0.68	1	0.67	1
9	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.53	1	0.74	1	0.67	1	0.66	1	0.64	1	0.53	1	0.59	1	0.58	1	0.56	1	0.62	1	0.53	1	0.54	1	0.68	1	0.60	1	0.59	1	0.56	1	0.53	1	0.59	1	0.58	1	0.54	1	0.56	1	0.54	1	0.59	1
	III	0.31	1	0.52	1	0.44	1	0.42	1	0.41	1	0.31	1	0.38	1	0.35	1	0.34	1	0.39	1	0.30	1	0.31	1	0.45	1	0.37	1	0.35	1	0.33	1	0.31	1	0.37	1	0.35	1	0.31	1	0.34	1	0.31	1	0.36	1
	IV	0.42	1	0.67	1	0.57	1	0.56	1	0.54	1	0.41	1	0.48	1	0.47	1	0.45	1	0.52	1	0.41	1	0.41	1	0.59	1	0.50	1	0.47	1	0.45	1	0.41	1	0.48	1	0.46	1	0.42	1	0.44	1	0.43	1	0.48	1
	Average	0.57	1	0.73	1	0.67	1	0.66	1	0.65	1	0.56	1	0.61	1	0.60	1	0.59	1	0.63	1	0.56	1	0.57	1	0.68	1	0.62	1	0.60	1	0.59	1	0.56	1	0.61	1	0.60	1	0.57	1	0.59	1	0.57	1	0.61	1
10	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.53	1	0.69	1	0.52	1	0.53	1	0.58	1	0.57	1	0.58	1	0.57	1	0.56	1	0.52	1	0.47	1	0.56	1	0.65	1	0.56	1	0.55	1	0.53	1	0.53	1	0.58	1	0.57	1	0.52	1	0.56	1	0.53	1	0.56	1
	III	0.31	1	0.45	1	0.30	1	0.33	1	0.34	1	0.34	1	0.36	1	0.35	1	0.34	1	0.32	1	0.26	1	0.34	1	0.42	1	0.34	1	0.33	1	0.32	1	0.31	1	0.35	1	0.34	1	0.31	1	0.34	1	0.33	1	0.34	1
	IV	0.41	1	0.59	1	0.41	1	0.41	1	0.44	1	0.46	1	0.46	1	0.45	1	0.45	1	0.41	1	0.34	1	0.45	1	0.54	1	0.44	1	0.43	1	0.42	1	0.41	1	0.47	1	0.46	1	0.41	1	0.45	1	0.42	1	0.44	1
	Average	0.56	1	0.68	1	0.56	1	0.57	1	0.59	1	0.59	1	0.60	1	0.59	1	0.59	1	0.56	1	0.52	1	0.59	1	0.65	1	0.59	1	0.58	1	0.57	1	0.56	1	0.60	1	0.59	1	0.56	1	0.59	1	0.57	1	0.58	1

Table F.4. Water Quality Reliability Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																																												Average	
		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22			
		CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ
11	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.79	1	0.81	1	0.80	1	0.80	1	0.80	1	0.79	1	0.79	1	0.79	1	0.79	1	0.79	1	0.79	1	0.79	1	0.42	1	0.78	1	0.78	1	0.79	1	0.79	1	0.78	1	0.78	1	0.79	1	0.79	1	0.79	1	0.77	1
	III	0.58	1	0.60	1	0.59	1	0.59	1	0.59	1	0.58	1	0.59	1	0.59	1	0.59	1	0.59	1	0.58	1	0.58	1	0.21	1	0.57	1	0.57	1	0.58	1	0.58	1	0.56	1	0.57	1	0.58	1	0.57	1	0.58	1	0.56	1
	IV	0.72	1	0.75	1	0.74	1	0.73	1	0.73	1	0.72	1	0.73	1	0.73	1	0.73	1	0.73	1	0.72	1	0.72	1	0.23	1	0.71	1	0.72	1	0.72	1	0.72	1	0.71	1	0.71	1	0.72	1	0.72	1	0.72	1	0.70	1
	Average	0.77	1	0.79	1	0.78	1	0.78	1	0.78	1	0.77	1	0.78	1	0.78	1	0.78	1	0.78	1	0.77	1	0.77	1	0.47	1	0.77	1	0.77	1	0.77	1	0.77	1	0.76	1	0.77	1	0.77	1	0.77	1	0.77	1	0.76	1
12	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.75	1	0.80	1	0.77	1	0.77	1	0.77	1	0.75	1	0.76	1	0.76	1	0.76	1	0.76	1	0.75	1	0.75	1	0.57	1	0.49	1	0.69	1	0.75	1	0.75	1	0.75	1	0.75	1	0.75	1	0.75	1	0.75	1	0.73	1
	III	0.53	1	0.58	1	0.56	1	0.55	1	0.55	1	0.53	1	0.55	1	0.55	1	0.54	1	0.55	1	0.54	1	0.53	1	0.34	1	0.27	1	0.47	1	0.53	1	0.54	1	0.53	1	0.53	1	0.54	1	0.53	1	0.53	1	0.52	1
	IV	0.68	1	0.73	1	0.70	1	0.70	1	0.69	1	0.68	1	0.69	1	0.68	1	0.68	1	0.68	1	0.68	1	0.68	1	0.45	1	0.37	1	0.60	1	0.67	1	0.68	1	0.67	1	0.68	1	0.68	1	0.67	1	0.67	1	0.66	1
	Average	0.74	1	0.78	1	0.76	1	0.76	1	0.75	1	0.74	1	0.75	1	0.75	1	0.75	1	0.75	1	0.74	1	0.74	1	0.59	1	0.53	1	0.69	1	0.74	1	0.74	1	0.74	1	0.74	1	0.74	1	0.74	1	0.74	1	0.73	1
13	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.64	1	0.76	1	0.70	1	0.69	1	0.68	1	0.64	1	0.67	1	0.66	1	0.66	1	0.66	1	0.67	1	0.64	1	0.66	1	0.62	1	0.60	1	0.65	1	0.67	1	0.68	1	0.69	1	0.67	1	0.64	1	0.64	1	0.66	1
	III	0.41	1	0.54	1	0.47	1	0.46	1	0.45	1	0.42	1	0.44	1	0.44	1	0.43	1	0.44	1	0.44	1	0.41	1	0.43	1	0.39	1	0.36	1	0.42	1	0.43	1	0.46	1	0.47	1	0.43	1	0.40	1	0.40	1	0.43	1
	IV	0.54	1	0.68	1	0.61	1	0.60	1	0.59	1	0.55	1	0.57	1	0.57	1	0.56	1	0.57	1	0.57	1	0.54	1	0.56	1	0.52	1	0.49	1	0.55	1	0.57	1	0.59	1	0.60	1	0.57	1	0.53	1	0.54	1	0.57	1
	Average	0.65	1	0.75	1	0.70	1	0.69	1	0.68	1	0.65	1	0.67	1	0.67	1	0.66	1	0.67	1	0.67	1	0.65	1	0.66	1	0.63	1	0.61	1	0.66	1	0.67	1	0.68	1	0.69	1	0.67	1	0.64	1	0.65	1	0.67	1
14	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.42	1	0.72	1	0.61	1	0.59	1	0.57	1	0.46	1	0.53	1	0.47	1	0.45	1	0.42	1	0.55	1	0.43	1	0.61	1	0.43	1	0.43	1	0.44	1	0.54	1	0.53	1	0.50	1	0.43	1	0.51	1	0.44	1	0.50	1
	III	0.26	1	0.48	1	0.37	1	0.35	1	0.32	1	0.27	1	0.29	1	0.28	1	0.27	1	0.22	1	0.31	1	0.26	1	0.38	1	0.23	1	0.23	1	0.26	1	0.30	1	0.30	1	0.29	1	0.25	1	0.29	1	0.25	1	0.29	1
	IV	0.29	1	0.63	1	0.50	1	0.48	1	0.45	1	0.33	1	0.39	1	0.35	1	0.32	1	0.29	1	0.43	1	0.31	1	0.49	1	0.31	1	0.30	1	0.30	1	0.42	1	0.41	1	0.38	1	0.30	1	0.40	1	0.32	1	0.38	1
	Average	0.49	1	0.71	1	0.62	1	0.61	1	0.59	1	0.52	1	0.55	1	0.53	1	0.51	1	0.48	1	0.57	1	0.50	1	0.62	1	0.49	1	0.49	1	0.50	1	0.57	1	0.56	1	0.54	1	0.50	1	0.55	1	0.50	1	0.54	1
15	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.73	1	0.79	1	0.76	1	0.75	1	0.75	1	0.73	1	0.75	1	0.74	1	0.74	1	0.74	1	0.74	1	0.73	1	0.46	1	0.74	1	0.74	1	0.73	1	0.74	1	0.57	1	0.61	1	0.73	1	0.71	1	0.73	1	0.71	1
	III	0.51	1	0.58	1	0.54	1	0.53	1	0.53	1	0.52	1	0.52	1	0.52	1	0.52	1	0.52	1	0.52	1	0.51	1	0.25	1	0.52	1	0.52	1	0.51	1	0.52	1	0.34	1	0.38	1	0.51	1	0.49	1	0.51	1	0.49	1
	IV	0.65	1	0.72	1	0.68	1	0.68	1	0.67	1	0.65	1	0.67	1	0.66	1	0.66	1	0.66	1	0.66	1	0.65	1	0.33	1	0.66	1	0.66	1	0.64	1	0.65	1	0.44	1	0.50	1	0.65	1	0.63	1	0.65	1	0.63	1
	Average	0.72	1	0.77	1	0.75	1	0.74	1	0.74	1	0.73	1	0.74	1	0.73	1	0.73	1	0.73	1	0.73	1	0.72	1	0.51	1	0.73	1	0.73	1	0.72	1	0.73	1	0.59	1	0.62	1	0.72	1	0.71	1	0.72	1	0.71	1
16	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.70	1	0.77	1	0.73	1	0.73	1	0.72	1	0.70	1	0.71	1	0.71	1	0.71	1	0.70	1	0.68	1	0.70	1	0.52	1	0.71	1	0.71	1	0.67	1	0.69	1	0.65	1	0.64	1	0.69	1	0.66	1	0.69	1	0.69	1
	III	0.46	1	0.56	1	0.51	1	0.50	1	0.49	1	0.47	1	0.48	1	0.48	1	0.48	1	0.48	1	0.46	1	0.47	1	0.29	1	0.48	1	0.48	1	0.45	1	0.47	1	0.41	1	0.40	1	0.45	1	0.43	1	0.45	1	0.46	1
	IV	0.60	1	0.70	1	0.65	1	0.64	1	0.64	1	0.61	1	0.63	1	0.62	1	0.62	1	0.61	1	0.59	1	0.61	1	0.39	1	0.62	1	0.62	1	0.58	1	0.60	1	0.54	1	0.54	1	0.60	1	0.57	1	0.60	1	0.60	1
	Average	0.69	1	0.76	1	0.72	1	0.72	1	0.71	1	0.70	1	0.71	1	0.70	1	0.70	1	0.70	1	0.68	1	0.70	1	0.55	1	0.70	1	0.70	1	0.68	1	0.69	1	0.65	1	0.65	1	0.69	1	0.67	1	0.69	1	0.69	1
17	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.60	1	0.74	1	0.67	1	0.66	1	0.65	1	0.62	1	0.63	1	0.63	1	0.62	1	0.58	1	0.62	1	0.60	1	0.58	1	0.61	1	0.61	1	0.59	1	0.62	1	0.45	1	0.42	1	0.60	1	0.45	1	0.56	1	0.60	1
	III	0.36	1	0.51	1	0.44	1	0.42	1	0.41	1	0.38	1	0.40	1	0.39	1	0.38	1	0.35	1	0.38	1	0.37	1	0.34	1	0.38	1	0.38	1	0.36	1	0.38	1	0.24	1	0.22	1	0.36	1	0.25	1	0.33	1	0.37	1
	IV	0.49	1	0.66	1	0.57	1	0.56	1	0.54	1	0.51	1	0.53	1	0.52	1	0.51	1	0.47	1	0.51	1	0.49	1	0.45	1	0.51	1	0.50	1	0.48	1	0.51	1	0.30	1	0.29	1	0.49	1	0.33	1	0.45	1	0.49	1
	Average	0.61	1	0.73	1	0.67	1	0.66	1	0.65	1	0.63	1	0.64	1	0.64	1	0.63	1	0.60	1	0.63	1	0.62	1	0.59	1	0.63	1	0.62	1	0.61	1	0.63	1	0.50	1	0.48	1	0.61	1	0.51	1	0.59	1	0.61	1

Note : CC = Residual Chlorine Concentration in mg/L
RQ = Water Quality Reliability
*) Refer to Table 4.11

Table F.5. Water Quality Reliability Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																																												Average	
		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22			
		CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ
2	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.73	1	0.48	1	0.71	1	0.72	1	0.72	1	0.73	1	0.73	1	0.73	1	0.73	1	0.73	1	0.73	1	0.73	1	0.75	1	0.73	1	0.73	1	0.73	1	0.73	1	0.73	1	0.73	1	0.73	1	0.73	1	0.73	1	0.72	1
	III	0.47	1	0.25	1	0.45	1	0.46	1	0.46	1	0.47	1	0.46	1	0.46	1	0.46	1	0.46	1	0.46	1	0.47	1	0.48	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.46	1
	IV	0.61	1	0.12	0	0.59	1	0.59	1	0.60	1	0.61	1	0.60	1	0.61	1	0.61	1	0.61	1	0.61	1	0.61	1	0.62	1	0.61	1	0.61	1	0.61	1	0.61	1	0.62	1	0.61	1	0.61	1	0.61	1	0.61	1	0.59	1
	Average	0.70	1	0.46	1	0.69	1	0.69	1	0.70	1	0.70	1	0.70	1	0.70	1	0.70	1	0.70	1	0.70	1	0.70	1	0.71	1	0.70	1	0.70	1	0.70	1	0.70	1	0.71	1	0.70	1	0.70	1	0.70	1	0.70	1	0.69	1
3	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.65	1	0.51	1	0.42	1	0.45	1	0.55	1	0.65	1	0.67	1	0.66	1	0.66	1	0.64	1	0.65	1	0.65	1	0.69	1	0.66	1	0.66	1	0.65	1	0.65	1	0.66	1	0.66	1	0.65	1	0.66	1	0.65	1	0.63	1
	III	0.38	1	0.26	1	0.25	1	0.36	1	0.30	1	0.38	1	0.40	1	0.40	1	0.40	1	0.38	1	0.38	1	0.38	1	0.43	1	0.40	1	0.39	1	0.39	1	0.38	1	0.41	1	0.40	1	0.39	1	0.39	1	0.39	1	0.37	1
	IV	0.52	1	0.37	1	0.28	1	0.25	1	0.41	1	0.51	1	0.54	1	0.53	1	0.53	1	0.51	1	0.51	1	0.51	1	0.57	1	0.53	1	0.53	1	0.52	1	0.51	1	0.54	1	0.53	1	0.52	1	0.53	1	0.52	1	0.49	1
	Average	0.64	1	0.54	1	0.49	1	0.52	1	0.57	1	0.64	1	0.65	1	0.65	1	0.65	1	0.63	1	0.64	1	0.64	1	0.67	1	0.65	1	0.65	1	0.64	1	0.64	1	0.65	1	0.65	1	0.64	1	0.65	1	0.64	1	0.62	1
4	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.60	1	0.59	1	0.54	1	0.48	1	0.42	1	0.60	1	0.64	1	0.63	1	0.63	1	0.59	1	0.60	1	0.60	1	0.66	1	0.62	1	0.62	1	0.60	1	0.60	1	0.63	1	0.62	1	0.60	1	0.61	1	0.60	1	0.59	1
	III	0.34	1	0.33	1	0.28	1	0.25	1	0.33	1	0.34	1	0.37	1	0.37	1	0.36	1	0.34	1	0.33	1	0.34	1	0.41	1	0.36	1	0.35	1	0.34	1	0.33	1	0.37	1	0.36	1	0.34	1	0.35	1	0.34	1	0.34	1
	IV	0.46	1	0.44	1	0.39	1	0.35	1	0.22	1	0.46	1	0.50	1	0.49	1	0.49	1	0.45	1	0.45	1	0.46	1	0.54	1	0.49	1	0.48	1	0.47	1	0.45	1	0.49	1	0.49	1	0.46	1	0.48	1	0.46	1	0.45	1
	Average	0.60	1	0.59	1	0.55	1	0.52	1	0.49	1	0.60	1	0.63	1	0.62	1	0.62	1	0.60	1	0.60	1	0.60	1	0.65	1	0.62	1	0.61	1	0.60	1	0.60	1	0.62	1	0.62	1	0.60	1	0.61	1	0.60	1	0.60	1
5	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.55	1	0.64	1	0.60	1	0.59	1	0.59	1	0.54	1	0.61	1	0.60	1	0.59	1	0.54	1	0.54	1	0.55	1	0.63	1	0.58	1	0.57	1	0.55	1	0.54	1	0.59	1	0.58	1	0.55	1	0.56	1	0.55	1	0.57	1
	III	0.29	1	0.37	1	0.33	1	0.33	1	0.33	1	0.29	1	0.35	1	0.34	1	0.33	1	0.28	1	0.28	1	0.29	1	0.38	1	0.32	1	0.31	1	0.30	1	0.29	1	0.33	1	0.32	1	0.30	1	0.31	1	0.29	1	0.32	1
	IV	0.41	1	0.49	1	0.46	1	0.46	1	0.44	1	0.40	1	0.47	1	0.46	1	0.45	1	0.39	1	0.40	1	0.41	1	0.51	1	0.44	1	0.43	1	0.41	1	0.40	1	0.45	1	0.44	1	0.41	1	0.43	1	0.41	1	0.44	1
	Average	0.56	1	0.63	1	0.60	1	0.60	1	0.59	1	0.56	1	0.61	1	0.60	1	0.59	1	0.55	1	0.56	1	0.56	1	0.63	1	0.59	1	0.58	1	0.57	1	0.56	1	0.59	1	0.59	1	0.57	1	0.58	1	0.56	1	0.58	1
6	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.46	1	0.45	1	0.44	1	0.46	1	0.47	1	0.43	1	0.49	1	0.49	1	0.49	1	0.45	1	0.48	1	0.43	1	0.56	1	0.47	1	0.48	1	0.45	1	0.43	1	0.51	1	0.49	1	0.45	1	0.49	1	0.46	1	0.47	1
	III	0.22	1	0.25	1	0.21	1	0.24	1	0.23	1	0.20	1	0.25	1	0.24	1	0.24	1	0.21	1	0.24	1	0.20	1	0.31	1	0.23	1	0.23	1	0.22	1	0.20	1	0.25	1	0.25	1	0.21	1	0.24	1	0.22	1	0.23	1
	IV	0.31	1	0.30	1	0.29	1	0.32	1	0.33	1	0.29	1	0.35	1	0.35	1	0.34	1	0.31	1	0.34	1	0.29	1	0.43	1	0.33	1	0.33	1	0.32	1	0.29	1	0.36	1	0.35	1	0.31	1	0.35	1	0.32	1	0.33	1
	Average	0.50	1	0.50	1	0.49	1	0.51	1	0.51	1	0.48	1	0.52	1	0.52	1	0.52	1	0.49	1	0.52	1	0.48	1	0.58	1	0.51	1	0.51	1	0.50	1	0.48	1	0.53	1	0.52	1	0.49	1	0.52	1	0.50	1	0.51	1
7	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.68	1	0.42	1	0.69	1	0.68	1	0.69	1	0.68	1	0.41	1	0.56	1	0.63	1	0.67	1	0.68	1	0.68	1	0.71	1	0.69	1	0.68	1	0.67	1	0.68	1	0.69	1	0.69	1	0.68	1	0.68	1	0.67	1	0.65	1
	III	0.41	1	0.28	1	0.42	1	0.42	1	0.42	1	0.41	1	0.29	1	0.31	1	0.37	1	0.41	1	0.41	1	0.41	1	0.45	1	0.42	1	0.42	1	0.41	1	0.41	1	0.42	1	0.42	1	0.41	1	0.42	1	0.41	1	0.40	1
	IV	0.54	1	0.19	0	0.55	1	0.56	1	0.55	1	0.54	1	0.26	1	0.42	1	0.50	1	0.54	1	0.54	1	0.54	1	0.59	1	0.56	1	0.55	1	0.54	1	0.54	1	0.56	1	0.56	1	0.54	1	0.55	1	0.55	1	0.51	1
	Average	0.66	1	0.47	1	0.67	1	0.67	1	0.67	1	0.66	1	0.49	1	0.57	1	0.63	1	0.66	1	0.66	1	0.66	1	0.69	1	0.67	1	0.66	1	0.66	1	0.66	1	0.67	1	0.67	1	0.66	1	0.66	1	0.66	1	0.64	1
8	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.61	1	0.54	1	0.65	1	0.64	1	0.65	1	0.60	1	0.53	1	0.46	1	0.48	1	0.60	1	0.60	1	0.61	1	0.67	1	0.63	1	0.62	1	0.61	1	0.60	1	0.63	1	0.63	1	0.61	1	0.62	1	0.61	1	0.60	1
	III	0.35	1	0.28	1	0.38	1	0.38	1	0.38	1	0.35	1	0.28	1	0.22	1	0.24	1	0.34	1	0.35	1	0.35	1	0.41	1	0.37	1	0.36	1	0.35	1	0.35	1	0.37	1	0.36	1	0.35	1	0.36	1	0.35	1	0.34	1
	IV	0.47	1	0.39	1	0.51	1	0.51	1	0.50	1	0.47	1	0.39	1	0.32	1	0.34	1	0.46	1	0.46	1	0.47	1	0.54	1	0.49	1	0.49	1	0.48	1	0.46	1	0.50	1	0.49	1	0.47	1	0.49	1	0.47	1	0.46	1
	Average	0.61	1	0.55	1	0.64	1	0.63	1	0.63	1	0.61	1	0.55	1	0.50	1	0.52	1	0.60	1	0.60	1	0.61	1	0.66	1	0.62	1	0.62	1	0.61	1	0.60	1	0.63	1	0.62	1	0.61	1	0.62	1	0.61	1	0.60	1
9	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.46	1	0.69	1	0.61	1	0.59	1	0.58	1	0.46	1	0.55	1	0.51	1	0.50	1	0.56	1	0.46	1	0.47	1	0.60	1	0.54	1	0.52	1	0.50	1	0.46	1	0.53	1	0.50	1	0.47	1	0.51	1	0.47	1	0.52	1
	III	0.22	1	0.41	1	0.33	1	0.32	1	0.31	1	0.22	1	0.29	1	0.29	1	0.25	1	0.29	1	0.23	1	0.22	1	0.35	1	0.28	1	0.27	1	0.24	1	0.22	1	0.27	1	0.26	1	0.23	1	0.26	1	0.23	1	0.27	1
	IV	0.32	1	0.55	1	0.46	1	0.44	1	0.43	1	0.32	1	0.38	1	0.37	1	0.35	1	0.41	1	0.32	1	0.32	1	0.48	1	0.39	1	0.38	1	0.35	1	0.32	1	0.38	1	0.36	1	0.33	1	0.34	1	0.33	1	0.38	1
	Average	0.50	1	0.66	1	0.60	1	0.59	1	0.58	1	0.50	1	0.56	1	0.54	1	0.53	1	0.57	1	0.50	1	0.50	1	0.61	1	0.55	1	0.54	1	0.52	1	0.50	1	0.55	1	0.53	1	0.51	1	0.53	1	0.51	1	0.54	1
10	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.46	1	0.62	1	0.46	1	0.46	1	0.52	1	0.51	1	0.52	1	0.51	1	0.50	1	0.46	1	0.42	1	0.49	1	0.58	1	0.49	1	0.48	1	0.48	1	0.47	1	0.52	1	0.50	1	0.46	1	0.50	1	0.47	1	0.49	1
	III	0.23	1	0.35	1	0.25	1	0.26	1	0.26	1	0.25	1	0.27	1	0.27	1	0.26	1	0.24	1	0.19	0	0.25	1	0.32	1	0.26	1	0.25	1	0.23	1	0.22	1	0.27	1	0.26	1	0.23	1	0.26	1	0.25	1	0.26	1
	IV	0.31	1	0.47	1	0.32	1	0.32	1	0.35	1	0.36	1	0.37	1	0.36	1	0.35	1	0.31	1	0.26	1	0.35	1	0.44	1	0.34	1	0.33	1	0.32	1	0.32	1	0.37	1	0.36	1	0.32	1	0.36	1	0.33	1	0.35	1
	Average	0.50	1	0.61	1	0.51	1	0.51	1	0.53	1	0.53	1	0.54	1	0.54	1	0.53	1	0.50	1	0.47	1	0.52	1	0.59	1	0.52	1	0.52	1	0.51	1	0.50	1	0.54	1	0.53	1	0.50	1	0.53	1	0.51	1	0.52	1

Table F.5. Water Quality Reliability Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																																												Average	
		1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22			
		CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ	CC	RQ
11	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.74	1	0.76	1	0.75	1	0.74	1	0.74	1	0.74	1	0.74	1	0.74	1	0.74	1	0.74	1	0.74	1	0.74	1	0.40	1	0.73	1	0.73	1	0.73	1	0.74	1	0.72	1	0.73	1	0.74	1	0.73	1	0.73	1	0.72	1
	III	0.47	1	0.49	1	0.48	1	0.48	1	0.48	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.47	1	0.21	1	0.46	1	0.46	1	0.47	1	0.47	1	0.46	1	0.46	1	0.47	1	0.47	1	0.47	1	0.46	1
	IV	0.61	1	0.63	1	0.62	1	0.62	1	0.62	1	0.61	1	0.62	1	0.62	1	0.62	1	0.62	1	0.61	1	0.61	1	0.18	0	0.60	1	0.60	1	0.60	1	0.61	1	0.59	1	0.60	1	0.61	1	0.60	1	0.61	1	0.59	1
	Average	0.71	1	0.72	1	0.71	1	0.71	1	0.71	1	0.71	1	0.71	1	0.71	1	0.71	1	0.71	1	0.71	1	0.71	1	0.45	1	0.70	1	0.70	1	0.70	1	0.71	1	0.69	1	0.70	1	0.71	1	0.70	1	0.70	1	0.69	1
12	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.70	1	0.74	1	0.72	1	0.71	1	0.71	1	0.70	1	0.71	1	0.70	1	0.70	1	0.70	1	0.70	1	0.70	1	0.48	1	0.42	1	0.63	1	0.69	1	0.70	1	0.69	1	0.70	1	0.70	1	0.69	1	0.69	1	0.68	1
	III	0.42	1	0.48	1	0.45	1	0.45	1	0.44	1	0.42	1	0.44	1	0.44	1	0.44	1	0.44	1	0.43	1	0.42	1	0.24	1	0.22	1	0.37	1	0.42	1	0.43	1	0.42	1	0.42	1	0.42	1	0.42	1	0.42	1	0.41	1
	IV	0.56	1	0.61	1	0.59	1	0.58	1	0.58	1	0.56	1	0.58	1	0.58	1	0.57	1	0.57	1	0.56	1	0.56	1	0.35	1	0.28	1	0.49	1	0.56	1	0.56	1	0.56	1	0.56	1	0.56	1	0.55	1	0.56	1	0.54	1
	Average	0.67	1	0.71	1	0.69	1	0.69	1	0.68	1	0.67	1	0.68	1	0.68	1	0.68	1	0.68	1	0.67	1	0.67	1	0.52	1	0.48	1	0.62	1	0.67	1	0.67	1	0.67	1	0.67	1	0.67	1	0.67	1	0.67	1	0.66	1
13	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.58	1	0.70	1	0.64	1	0.63	1	0.62	1	0.58	1	0.61	1	0.60	1	0.59	1	0.60	1	0.60	1	0.58	1	0.59	1	0.55	1	0.53	1	0.58	1	0.60	1	0.62	1	0.63	1	0.61	1	0.57	1	0.58	1	0.60	1
	III	0.31	1	0.43	1	0.37	1	0.36	1	0.35	1	0.32	1	0.34	1	0.34	1	0.33	1	0.34	1	0.34	1	0.31	1	0.33	1	0.29	1	0.28	1	0.32	1	0.34	1	0.36	1	0.37	1	0.34	1	0.30	1	0.31	1	0.34	1
	IV	0.43	1	0.56	1	0.50	1	0.49	1	0.47	1	0.43	1	0.46	1	0.46	1	0.44	1	0.45	1	0.46	1	0.43	1	0.45	1	0.41	1	0.39	1	0.44	1	0.46	1	0.48	1	0.49	1	0.46	1	0.42	1	0.43	1	0.46	1
	Average	0.58	1	0.67	1	0.63	1	0.62	1	0.61	1	0.58	1	0.60	1	0.60	1	0.59	1	0.60	1	0.60	1	0.58	1	0.59	1	0.56	1	0.55	1	0.59	1	0.60	1	0.62	1	0.62	1	0.60	1	0.57	1	0.58	1	0.60	1
14	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.36	1	0.66	1	0.54	1	0.52	1	0.50	1	0.42	1	0.47	1	0.44	1	0.39	1	0.36	1	0.48	1	0.37	1	0.54	1	0.36	1	0.37	1	0.39	1	0.47	1	0.46	1	0.43	1	0.37	1	0.45	1	0.38	1	0.44	1
	III	0.20	1	0.38	1	0.28	1	0.26	1	0.24	1	0.20	1	0.22	1	0.21	1	0.20	1	0.24	1	0.24	1	0.20	1	0.29	1	0.21	1	0.21	1	0.19	0	0.22	1	0.24	1	0.22	1	0.19	0	0.23	1	0.19	0	0.23	1
	IV	0.19	0	0.52	1	0.39	1	0.37	1	0.34	1	0.24	1	0.30	1	0.26	1	0.24	1	0.21	1	0.32	1	0.21	1	0.40	1	0.23	1	0.21	1	0.22	1	0.32	1	0.31	1	0.29	1	0.21	1	0.31	1	0.24	1	0.29	1
	Average	0.44	1	0.64	1	0.55	1	0.54	1	0.52	1	0.47	1	0.50	1	0.48	1	0.46	1	0.45	1	0.51	1	0.45	1	0.56	1	0.45	1	0.45	1	0.45	1	0.50	1	0.50	1	0.49	1	0.44	1	0.50	1	0.45	1	0.49	1
15	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.67	1	0.73	1	0.70	1	0.70	1	0.69	1	0.68	1	0.69	1	0.68	1	0.68	1	0.68	1	0.68	1	0.68	1	0.39	1	0.68	1	0.68	1	0.67	1	0.68	1	0.50	1	0.54	1	0.67	1	0.65	1	0.67	1	0.65	1
	III	0.41	1	0.46	1	0.43	1	0.43	1	0.42	1	0.41	1	0.42	1	0.42	1	0.42	1	0.41	1	0.41	1	0.41	1	0.18	0	0.41	1	0.41	1	0.40	1	0.41	1	0.25	1	0.29	1	0.40	1	0.38	1	0.40	1	0.39	1
	IV	0.53	1	0.61	1	0.57	1	0.56	1	0.55	1	0.53	1	0.55	1	0.55	1	0.55	1	0.55	1	0.54	1	0.53	1	0.24	1	0.55	1	0.54	1	0.53	1	0.54	1	0.36	1	0.41	1	0.53	1	0.52	1	0.53	1	0.52	1
	Average	0.65	1	0.70	1	0.68	1	0.67	1	0.67	1	0.66	1	0.67	1	0.66	1	0.66	1	0.66	1	0.66	1	0.66	1	0.45	1	0.66	1	0.66	1	0.65	1	0.66	1	0.53	1	0.56	1	0.65	1	0.64	1	0.65	1	0.64	1
16	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.64	1	0.72	1	0.67	1	0.67	1	0.66	1	0.64	1	0.65	1	0.65	1	0.65	1	0.64	1	0.62	1	0.64	1	0.43	1	0.65	1	0.65	1	0.61	1	0.63	1	0.58	1	0.58	1	0.63	1	0.60	1	0.63	1	0.63	1
	III	0.37	1	0.45	1	0.40	1	0.40	1	0.39	1	0.37	1	0.38	1	0.38	1	0.37	1	0.37	1	0.36	1	0.37	1	0.22	1	0.38	1	0.38	1	0.35	1	0.36	1	0.32	1	0.31	1	0.35	1	0.33	1	0.35	1	0.36	1
	IV	0.49	1	0.59	1	0.54	1	0.53	1	0.52	1	0.50	1	0.51	1	0.50	1	0.50	1	0.50	1	0.48	1	0.49	1	0.30	1	0.51	1	0.50	1	0.47	1	0.49	1	0.43	1	0.42	1	0.48	1	0.45	1	0.48	1	0.49	1
	Average	0.63	1	0.69	1	0.65	1	0.65	1	0.64	1	0.63	1	0.64	1	0.63	1	0.63	1	0.63	1	0.62	1	0.63	1	0.49	1	0.64	1	0.63	1	0.61	1	0.62	1	0.58	1	0.58	1	0.62	1	0.60	1	0.62	1	0.62	1
17	I	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
	II	0.54	1	0.69	1	0.61	1	0.60	1	0.58	1	0.55	1	0.57	1	0.56	1	0.55	1	0.52	1	0.55	1	0.54	1	0.50	1	0.55	1	0.55	1	0.53	1	0.56	1	0.39	1	0.35	1	0.54	1	0.39	1	0.50	1	0.53	1
	III	0.27	1	0.41	1	0.33	1	0.32	1	0.31	1	0.29	1	0.30	1	0.30	1	0.29	1	0.26	1	0.30	1	0.28	1	0.25	1	0.29	1	0.28	1	0.27	1	0.29	1	0.18	0	0.19	0	0.27	1	0.18	0	0.24	1	0.28	1
	IV	0.38	1	0.55	1	0.46	1	0.44	1	0.43	1	0.40	1	0.42	1	0.41	1	0.40	1	0.37	1	0.40	1	0.39	1	0.36	1	0.40	1	0.39	1	0.38	1	0.40	1	0.22	1	0.22	1	0.38	1	0.24	1	0.35	1	0.38	1
	Average	0.55	1	0.66	1	0.60	1	0.59	1	0.58	1	0.56	1	0.57	1	0.57	1	0.56	1	0.54	1	0.56	1	0.55	1	0.53	1	0.56	1	0.56	1	0.55	1	0.56	1	0.45	1	0.44	1	0.55	1	0.45	1	0.52	1	0.55	1

Note : CC = Residual Chlorine Concentration in mg/L
RQ = Water Quality Reliability
*) Refer to Table 4.11

Table G.1. Overall System Quality Reliability Under Average Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Quality Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
3	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.562	0.565	0.547	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.986
	Average	0.547	0.558	0.565	0.556	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.992
4	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.547	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.986
	IV	0.547	0.562	0.565	0.559	0.547	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.986
	Average	0.547	0.562	0.565	0.556	0.556	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.993
5	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
6	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.547	0.547	0.547	0.547	0.568	0.547	0.547	0.547	0.561	0.547	0.567	0.560	0.547	0.547	0.547	0.564	0.547	0.547	0.562	0.547	0.547	0.733
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.933
7	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
8	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.547	0.547	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.954
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.555	0.558	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.989
9	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.547	0.558	0.562	0.569	0.561	0.547	0.567	0.560	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.567	0.814
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.563	0.558	0.562	0.569	0.561	0.559	0.567	0.560	0.556	0.563	0.557	0.560	0.559	0.556	0.558	0.563	0.567	0.953

Table G.1. Overall System Quality Reliability Under Average Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Quality Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.000	0.015	0.018	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.013	0.000	0.000	0.000	0.000	0.016	0.012	0.000	0.021	0.000	0.140
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.410	0.425	0.428	0.419	0.423	0.426	0.419	0.422	0.426	0.421	0.426	0.425	0.424	0.420	0.426	0.420	0.423	0.427	0.423	0.422	0.432	0.425	0.785
11	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
12	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.547	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.971
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.556	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.993
13	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
14	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.561	0.547	0.567	0.547	0.559	0.569	0.547	0.547	0.547	0.547	0.562	0.547	0.567	0.753
	IV	0.000	0.015	0.018	0.012	0.012	0.000	0.011	0.015	0.000	0.000	0.015	0.000	0.013	0.000	0.000	0.000	0.017	0.016	0.012	0.000	0.021	0.000	0.201
	Average	0.410	0.425	0.424	0.419	0.420	0.421	0.419	0.422	0.421	0.421	0.422	0.425	0.420	0.420	0.426	0.417	0.423	0.423	0.420	0.422	0.426	0.425	0.739
15	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.547	0.559	0.562	0.569	0.567	0.981
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.559	0.559	0.562	0.569	0.567	0.992
16	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
17	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.000	0.015	0.018	0.012	0.012	0.021	0.011	0.015	0.021	0.000	0.015	0.000	0.000	0.012	0.021	0.000	0.017	0.016	0.012	0.000	0.021	0.000	0.272
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.547	0.547	0.562	0.547	0.567	0.943
	Average	0.410	0.425	0.428	0.422	0.423	0.431	0.421	0.425	0.432	0.421	0.426	0.425	0.420	0.423	0.432	0.420	0.427	0.423	0.420	0.422	0.426	0.425	0.804
																			Overall System Quality Reliability					0.943

*) Refer to Table 4.11

Table G.2. Overall System Water Quality Reliability Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Quality Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
3	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.547	0.547	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.963
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.558	0.561	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.991
4	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.547	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.986
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.556	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.997
5	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
6	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.410	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.421	0.754
7	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.547	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.988
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.555	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.993
8	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.547	0.547	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.959
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.558	0.563	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.990
9	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.000	0.015	0.018	0.012	0.012	0.000	0.011	0.015	0.000	0.014	0.000	0.000	0.013	0.012	0.021	0.000	0.000	0.016	0.012	0.000	0.021	0.000	0.219
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.410	0.425	0.428	0.422	0.423	0.426	0.421	0.425	0.426	0.424	0.422	0.425	0.424	0.423	0.432	0.420	0.423	0.427	0.423	0.422	0.432	0.425	0.805

Table G.2. Overall System Water Quality Reliability Under Maximum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Quality Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.000	0.015	0.000	0.012	0.012	0.021	0.011	0.015	0.021	0.000	0.000	0.000	0.013	0.012	0.021	0.000	0.000	0.016	0.000	0.000	0.000	0.020	0.215
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.410	0.425	0.424	0.422	0.423	0.431	0.421	0.425	0.432	0.421	0.422	0.425	0.424	0.423	0.432	0.420	0.423	0.427	0.420	0.422	0.426	0.430	0.804
11	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.554	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.993
12	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.547	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.971
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.556	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.993
13	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
14	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.000	0.015	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.052
	IV	0.000	0.015	0.018	0.012	0.012	0.021	0.011	0.015	0.021	0.000	0.015	0.020	0.013	0.012	0.021	0.000	0.017	0.016	0.012	0.015	0.021	0.020	0.349
	Average	0.274	0.288	0.291	0.283	0.283	0.289	0.282	0.285	0.290	0.280	0.285	0.289	0.287	0.283	0.290	0.280	0.286	0.286	0.283	0.285	0.290	0.289	0.600
15	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.559	0.562	0.569	0.567	0.966
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.559	0.559	0.562	0.569	0.567	0.992
16	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
17	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.547	0.547	0.562	0.547	0.547	0.921
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.547	0.562	0.569	0.567	0.986
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.559	0.553	0.562	0.563	0.562	0.977
																			Overall System Quality Reliability					0.921

*) Refer to Table 4.11

Table G.3. Overall System Quality Reliability Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Quality Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.555	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.992
3	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.547	0.565	0.559	0.547	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.969
	IV	0.547	0.562	0.547	0.547	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.966
	Average	0.547	0.558	0.561	0.556	0.556	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.984
4	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.547	0.547	0.547	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.950
	IV	0.547	0.562	0.565	0.559	0.547	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.986
	Average	0.547	0.558	0.561	0.556	0.556	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.984
5	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.000	0.015	0.018	0.012	0.012	0.000	0.011	0.015	0.021	0.000	0.000	0.000	0.013	0.012	0.000	0.000	0.000	0.016	0.012	0.000	0.000	0.000	0.179
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.410	0.425	0.428	0.422	0.423	0.426	0.421	0.425	0.432	0.421	0.422	0.425	0.424	0.423	0.426	0.420	0.423	0.427	0.423	0.422	0.426	0.425	0.795
6	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.547	0.547	0.547	0.547	0.568	0.547	0.547	0.547	0.561	0.547	0.567	0.547	0.547	0.547	0.560	0.564	0.547	0.547	0.562	0.547	0.547	0.733
	IV	0.547	0.547	0.565	0.559	0.559	0.547	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.960
	Average	0.547	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.923
7	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.547	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.547	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.971
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.555	0.558	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.989
8	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.547	0.565	0.559	0.559	0.568	0.547	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.971
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.555	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.993
9	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.547	0.547	0.547	0.547	0.569	0.547	0.547	0.567	0.560	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.732
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.556	0.563	0.555	0.558	0.569	0.557	0.559	0.567	0.560	0.556	0.563	0.557	0.560	0.559	0.556	0.558	0.563	0.562	0.933

Table G.3. Overall System Quality Reliability Under Minimum Demand During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Quality Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.049
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.547	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.410	0.425	0.424	0.419	0.420	0.426	0.419	0.422	0.426	0.421	0.422	0.425	0.424	0.420	0.426	0.420	0.423	0.423	0.420	0.422	0.426	0.425	0.758
11	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
12	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.547	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.971
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.547	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.986
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.553	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.989
13	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.000	0.015	0.018	0.012	0.012	0.021	0.011	0.015	0.021	0.014	0.015	0.020	0.013	0.000	0.021	0.013	0.017	0.016	0.012	0.015	0.000	0.000	0.319
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.410	0.425	0.428	0.422	0.423	0.431	0.421	0.425	0.432	0.424	0.426	0.430	0.424	0.420	0.432	0.424	0.427	0.427	0.423	0.425	0.426	0.425	0.830
14	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.055
	IV	0.000	0.015	0.018	0.012	0.012	0.000	0.011	0.000	0.000	0.000	0.015	0.000	0.013	0.000	0.000	0.000	0.017	0.016	0.000	0.000	0.000	0.000	0.146
	Average	0.274	0.288	0.287	0.283	0.283	0.284	0.282	0.281	0.284	0.284	0.285	0.284	0.284	0.280	0.284	0.280	0.286	0.286	0.280	0.281	0.284	0.289	0.550
15	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.547	0.547	0.562	0.569	0.567	0.953
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.554	0.559	0.569	0.560	0.564	0.559	0.556	0.562	0.569	0.567	0.984
16	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.547	0.562	0.569	0.567	0.971
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.554	0.559	0.569	0.560	0.564	0.564	0.556	0.562	0.569	0.567	0.989
17	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.000	0.015	0.018	0.012	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.089
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.547	0.547	0.562	0.547	0.567	0.943
	Average	0.410	0.425	0.428	0.422	0.423	0.426	0.419	0.422	0.426	0.421	0.422	0.425	0.420	0.420	0.426	0.420	0.423	0.419	0.416	0.422	0.426	0.425	0.758
																			Overall System Quality Reliability					0.893

*) Refer to Table 4.11

Table G.4. Overall System Quality Reliability Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Quality Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
3	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
4	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
5	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
6	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	1.000
7	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
8	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
9	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000

Table G.4. Overall System Quality Reliability Under Maximum Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Quality Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
11	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
12	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
13	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
14	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
15	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
16	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
17	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
																			Overall System Quality Reliability					1.000

*) Refer to Table 4.11

Table G.5. Overall System Quality Reliability Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Quality Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
3	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
4	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
5	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
6	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	0.558	1.000
7	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.547	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	Average	0.547	0.558	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
8	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
9	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000

Table G.5. Overall System Quality Reliability Under Average Demand and Minimum Supply During Various Demand Patterns

Node	Demand Pattern	State*																						Ov. Nodal Quality Rel.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
10	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.547	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.983
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.559	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
11	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
12	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
13	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
14	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.547	0.564	0.564	0.559	0.547	0.569	0.547	0.945
	IV	0.000	0.015	0.018	0.012	0.012	0.021	0.011	0.015	0.021	0.014	0.015	0.020	0.013	0.012	0.021	0.013	0.017	0.016	0.012	0.015	0.021	0.020	0.380
	Average	0.410	0.425	0.428	0.422	0.423	0.431	0.421	0.425	0.432	0.424	0.426	0.430	0.424	0.423	0.432	0.420	0.427	0.427	0.423	0.422	0.432	0.425	0.831
15	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.547	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.985
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.557	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	0.996
16	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
17	I	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	II	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	III	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.547	0.547	0.562	0.547	0.567	0.943
	IV	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.564	0.559	0.562	0.569	0.567	1.000
	Average	0.547	0.562	0.565	0.559	0.559	0.568	0.558	0.562	0.569	0.561	0.562	0.567	0.560	0.559	0.569	0.560	0.564	0.559	0.556	0.562	0.563	0.567	0.986
																			Overall System Quality Reliability					0.986

*) Refer to Table 4.11