LAMPIRAN

LAMPIRAN 1
SURAT-SURAT DALAM MELAKUKAN SURVEY

Depok, Mei 2008

Yth.
Ir. Wijoyo A Prakoso
Kepala Laboratorium Geologi Teknik dan Mekanika Tanah
Departemen Teknik Sipil FTUI

Dengan Hormat,

Tim peneliti PHK-B, Departemen Teknik Sipil, Univeristas Indonesia, hendak meminta data penelitian tanah dalam daerah Kota Depok, yang terdapat dalam beberapa laporan penelitian antara lain:

1. Laporan Penyelidikan Tanah Dinding Penahan Tanah
   Jl. Sentosa – Depok, Maret 2008
2. Proyek PJKA (PTKI) Depok, 2007

Data dari laporan-laporan ini akan kami pergunakan untuk penelitian PHK-B: *Green Infrastructure by Design*, dan juga untuk melengkapi data skripsi yang akan disusun oleh mahasiswa bernama Herjuna Rahman (NPM: 0403010356) dalam skripsinya yang berjudul: "Aplikasi 'Water Balance Model' Untuk Manajemen Air Hujan Perkotaan Dalam DAS Sugutamu, Jawa Barat, Indonesia".

Demikian, kami sampaikan. Mohon bantuan dan perhatian dari bapak.

Terima kasih.

PIC Penelitian PHK-B Bidan Air,
Dosen Pembimbing Skripsi Mahasiswa,
Departemen Teknik Sipil,

Dr-Ing. Ir. Dwita Sutjiningsih, Dipl-HE
NIP. 130 703 509

UNIVERSITAS INDONESIA
FAKULTAS TEKNIK
KAMPUS BARU U.I. DEPOK 16424
TELEPON : 7863503, 7863504, 7863505, 7270011, 78888430,
7863311, 78887861, 78888076, FAX. 7270050

SURAT KETERANGAN MAHASISWA

Nomor : 590 /PT.02.FT.01/I/2008....

Departemen Teknik Sipil Fakultas Teknik Universitas Indonesia, dengan ini menerangkan bahwa mahasiswa tersebut dibawah ini :

Nama	:	HERJUNA RAHMAN
Nomor Pokok	:	0403010356
Tempat & Tgl. Lahir	:	JAKARTA / 2 JUNI 1985
Nama Orangtua / ~~Wali~~	:	ABDUL KAPIR
Alamat Mahasiswa	:	KAV. POLRI AMPERA
		BLOK BN/30
		JAKARTA SELATAN 12550

Adalah benar mahasiswa Departemen Teknik Sipil Fakultas Teknik Universitas Indonesia, Kampus Universitas Indonesia, Depok, Jawa Barat.

Surat Keterangan ini diberikan untuk penelitian skripsi mahasiswa, dalam mencari data yang dibutuhkan, yaitu tata guna lahan dan kontur tanah di daerah sekitar Situ Baru, Depok, Jawa Barat.

Demikian Surat Keterangan ini dibuat, kepada yang bersangkutan harap mengetahuinya.

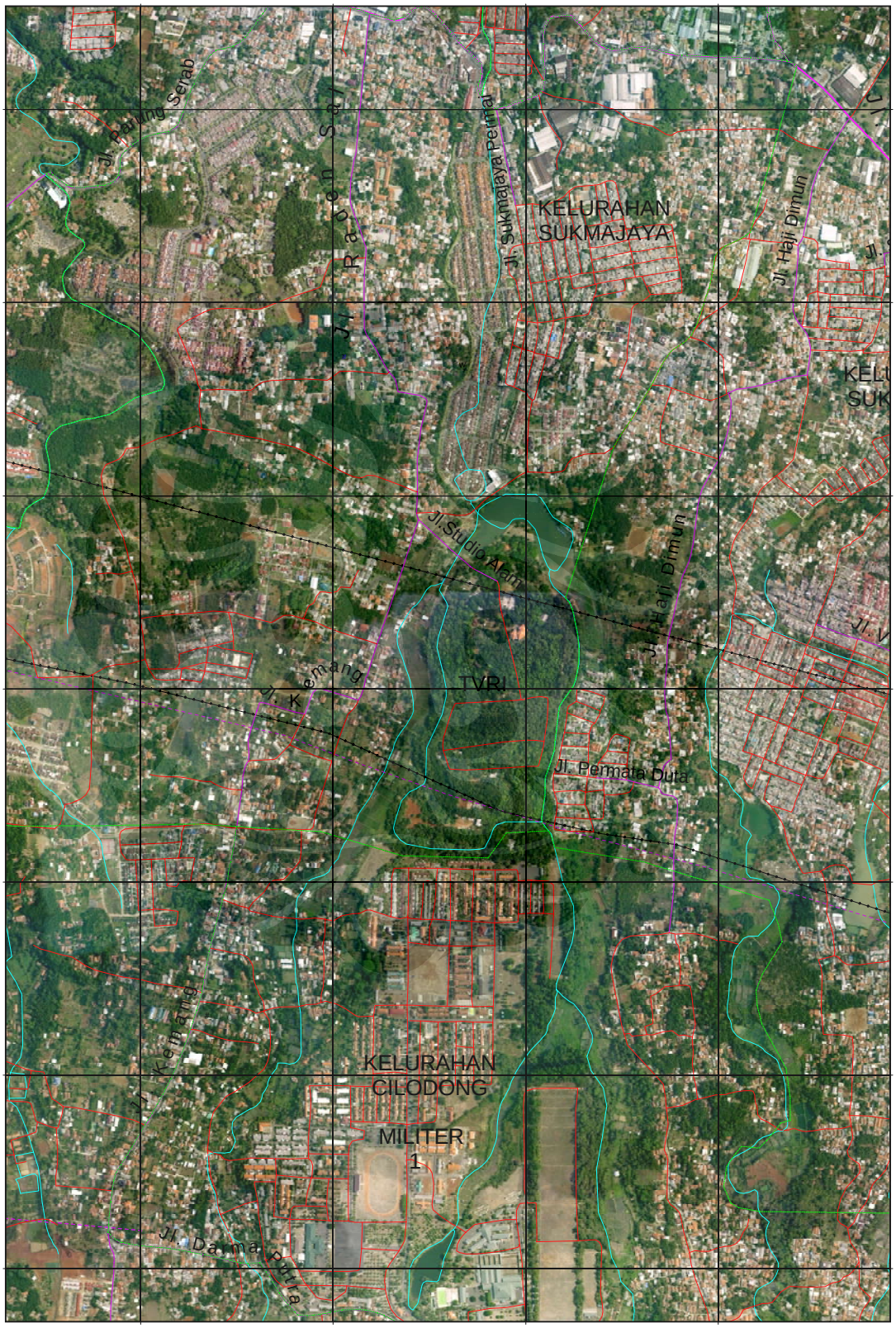
Depok, 16 MEI 2008

Departemen Teknik Sipil – FTUI
Ketua Departemen,

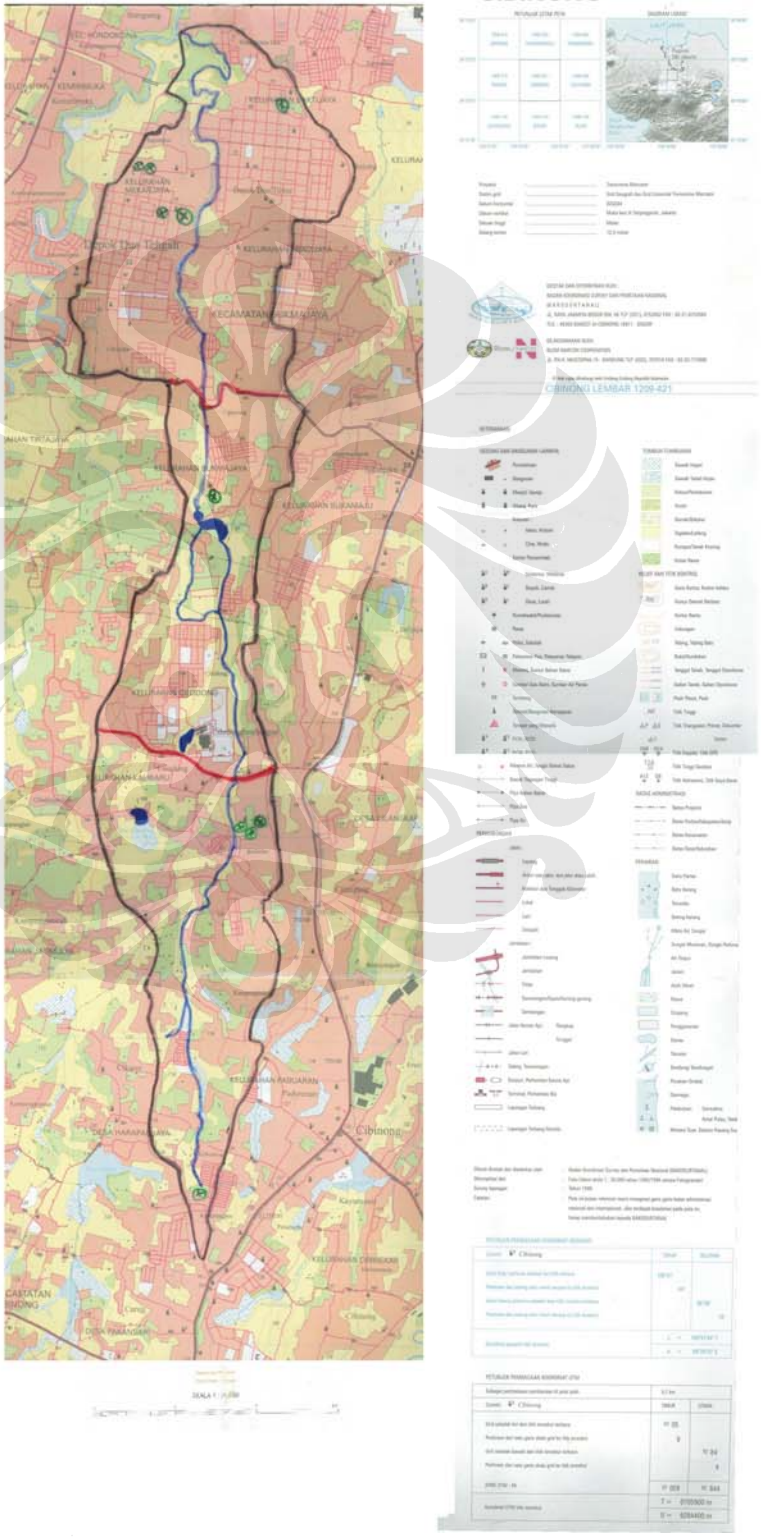
MULIA O.ST. M.ENG
Nama Jelas

- Pertinggal

LAMPIRAN 2
FOTO SATELIT *SUB-CATCHMENT* YANG DITINJAU


Jl. Parung Serab
Jl. Sukmajaya Permai
KELURAHAN
SUKMAJAYA
Jl. Haji Dimun
Jl. Studio Alam
Jl. Haji Dimun
TVRI
Jl. Permata Dura
KELURAHAN
CILODONG
MILITER
1
Jl. Darma Putra

LAMPIRAN 3
PETA-PETA SUB-DAS SUGUTAMU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Lembar 1209-421
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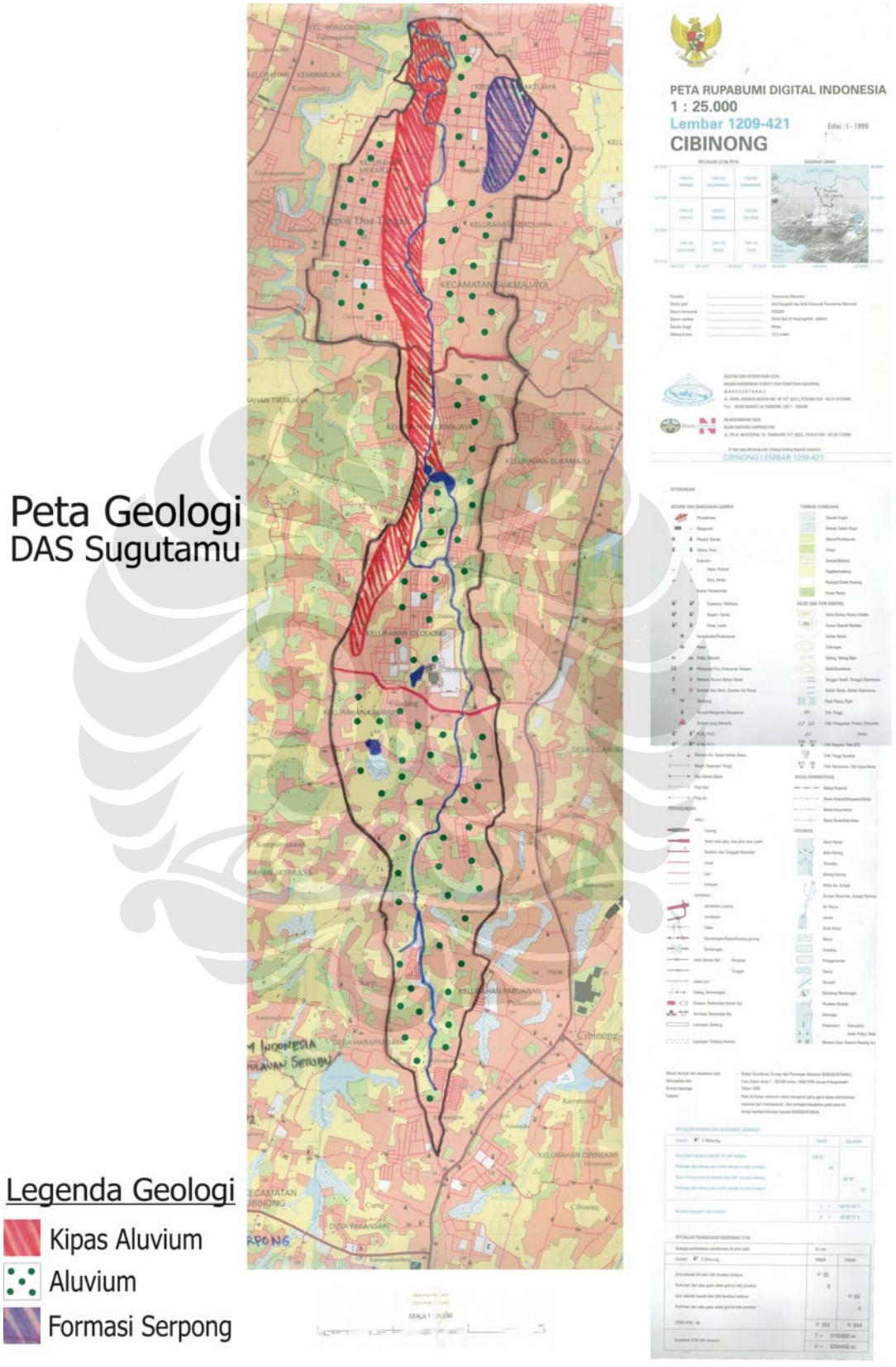
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Legenda Geologi
Kipas Aluvium
Aluvium
Formasi Serpong
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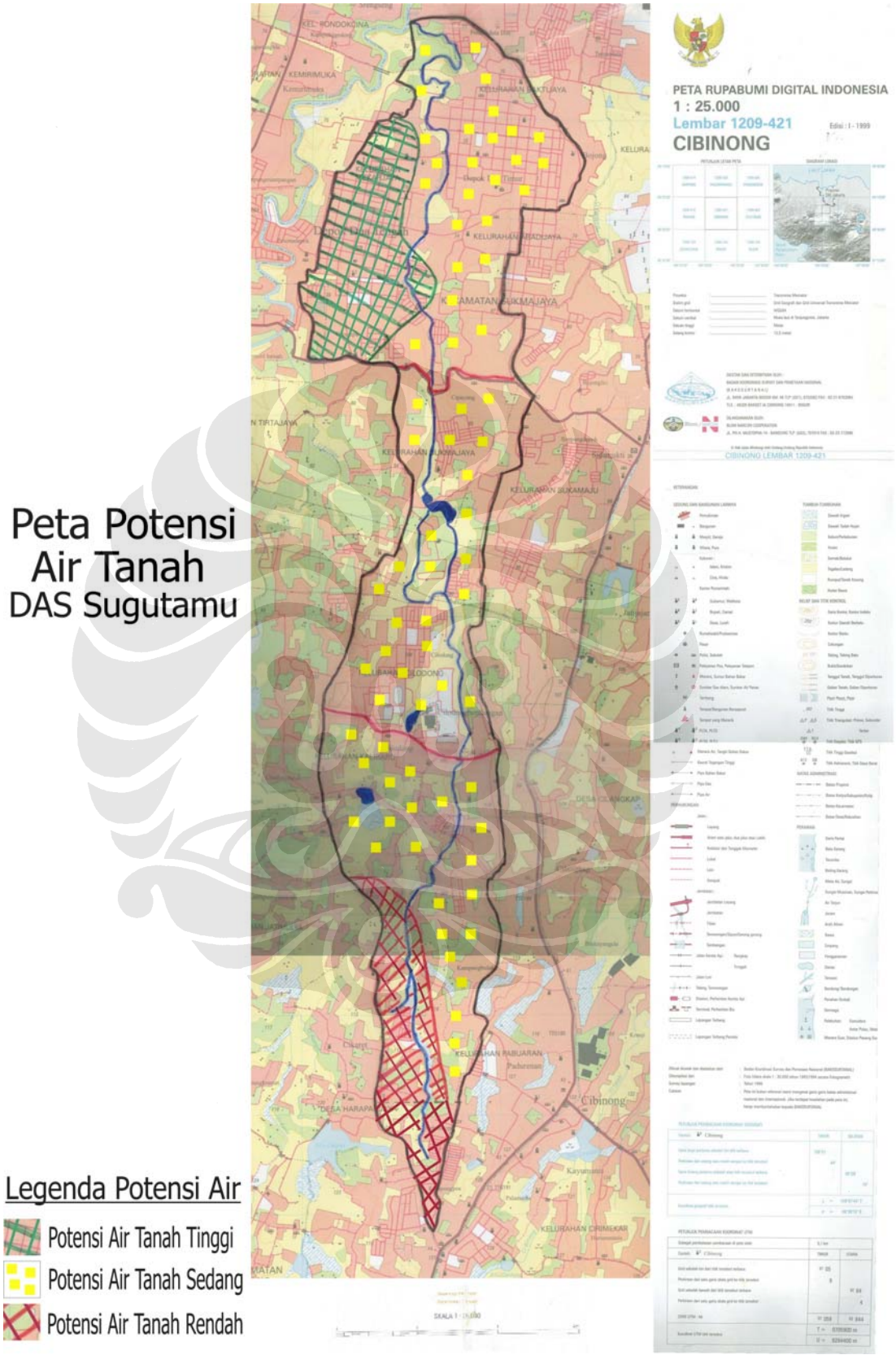
Lembar 1209-421
CIBINONG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Air Tanah
DAS Sugutamu
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Potensi Air Tanah Tinggi
Potensi Air Tanah Sedang
Potensi Air Tanah Rendah
PETA RUPABUMI DIGITAL INDONESIA
1 : 25.000
Lembar 1209-421
CIBINONG
Edisi : I - 1999
KELURAHAN RABUARAN
KELURAHAN CIRIMEKAR
DESA HARAPAN JAYA
Cibinong

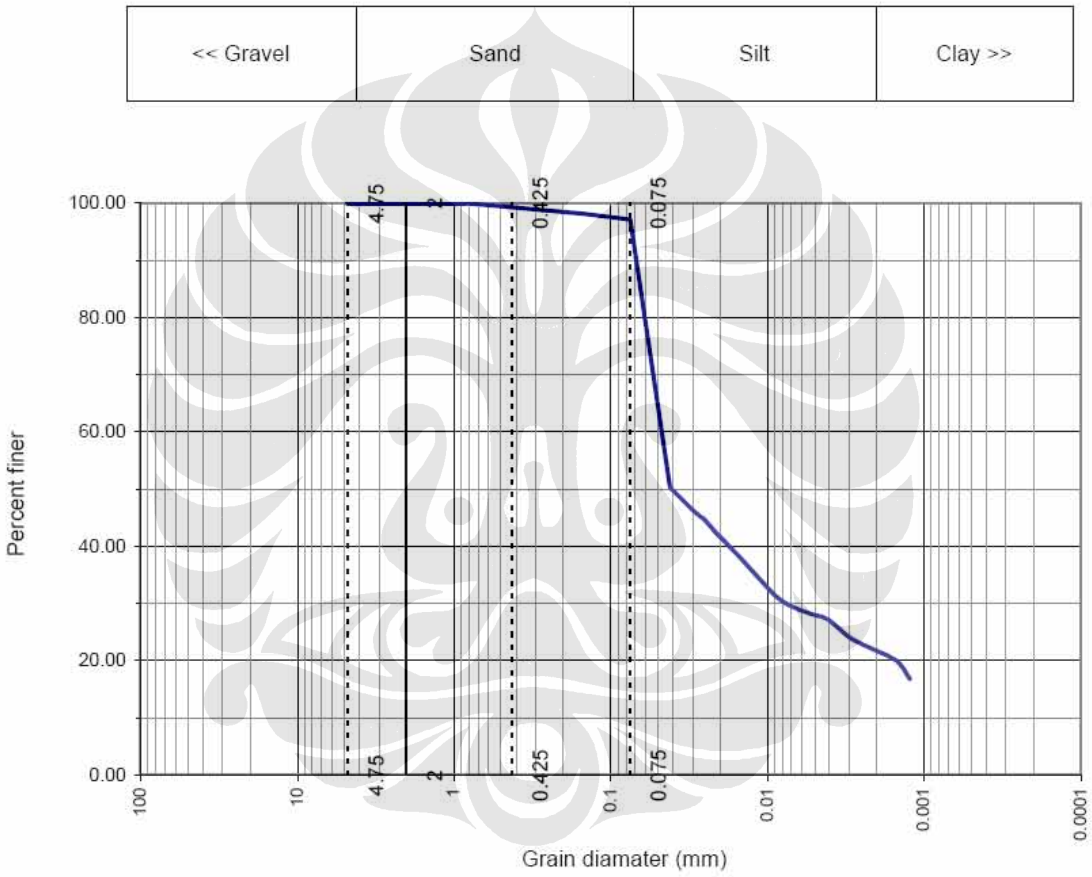
LAMPIRAN 4
DATA DISTRIBUSI BUTIRAN TANAH DI SUB-DAS SUGUTAMU

Soil Mechanics Laboratory
Civil Engineering Department, Faculty of Engineering University of Indonesia
Depok 16424 Telp. +62 21 788 49102, Fax. +62 21 788 49102

GRAIN SIZE DISTRIBUTION

PROJECT TURAP		**DEPTH OF SAMPLE** 1.50 - 2.00 m
LOCATION JL SENTOSA		**DATE OF TESTING** 28/02/08
BOREHOLE NO. HB 1	**SAMPLE NO.** 1	**TESTED BY** SUNARTO

PROJECT NUMBER: 200802001



Composition	
Sand	3 %
Silt	75 %
Clay	22 %

Visual Soil Description	CLAYEY SILT
Soil Classification	UNIFIED SOIL CLASSIFICATION

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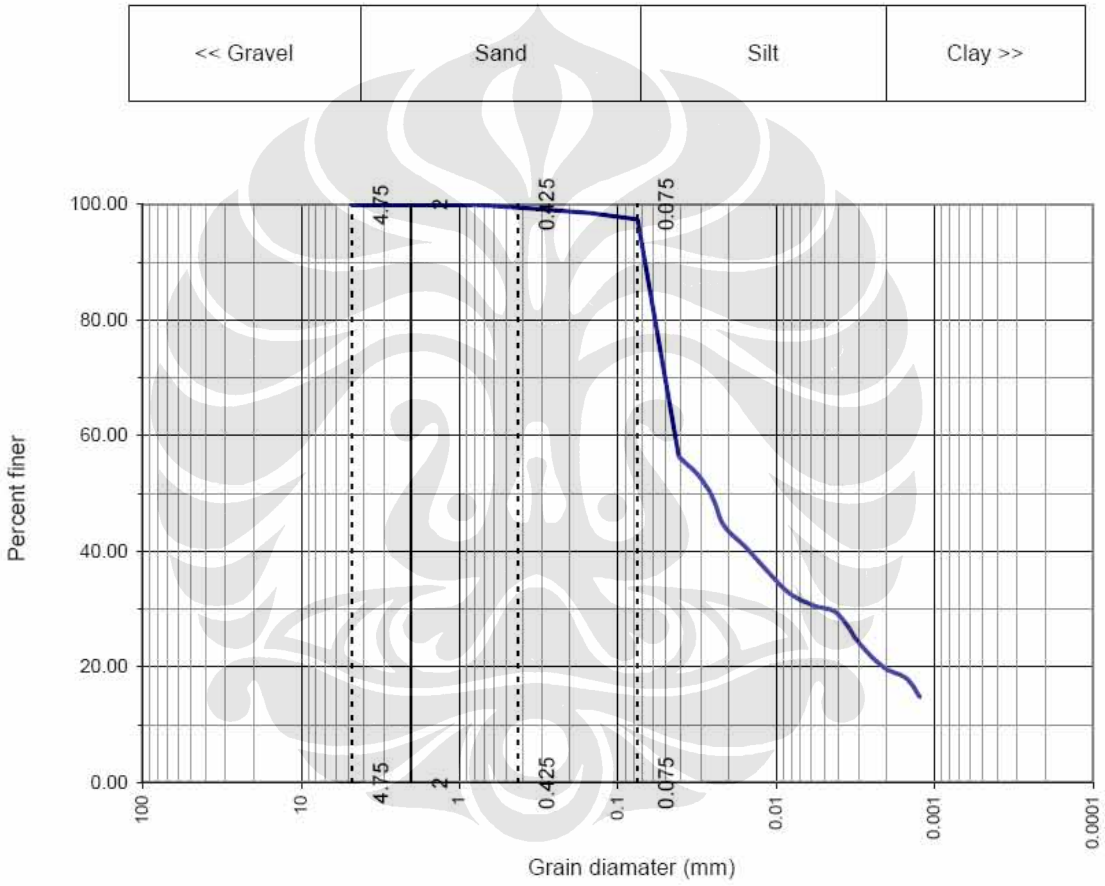
GRAIN SIZE DISTRIBUTION

PROJECT TURAP		**DEPTH OF SAMPLE** 3.00 - 3.50 m
LOCATION JL SENTOSA		**DATE OF TESTING** 28/02/08
BOREHOLE NO. HB 1	**SAMPLE NO.** 2	**TESTED BY** SUNARTO

PROJECT NUMBER: 200802001



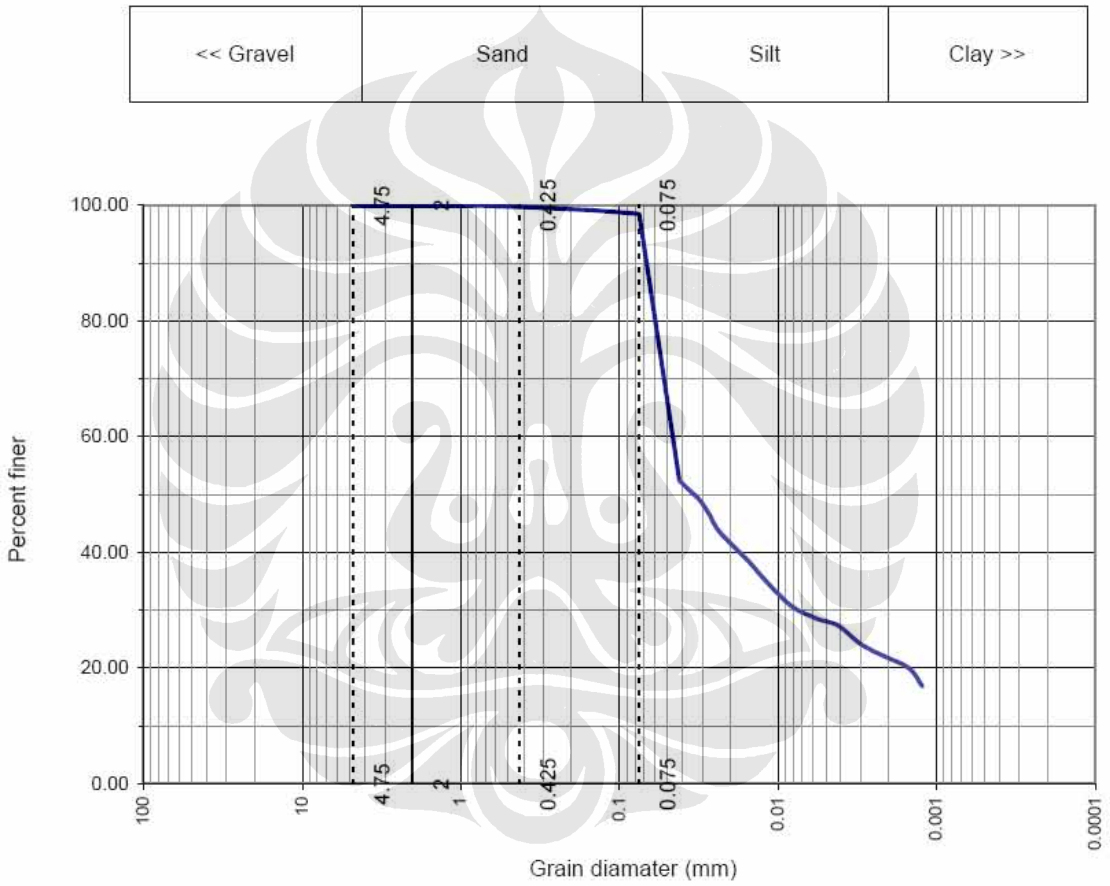
Composition	
Sand	2.5 %
Silt	77.5 %
Clay	20 %

Visual Soil Description	CLAYEY SILT
Soil Classification	UNIFIED SOIL CLASSIFICATION

Soil Mechanics Laboratory
Civil Engineering Department, Faculty of Engineering University of Indonesia
Depok 16424 Telp. +62 21 788 49102, Fax. +62 21 788 49102

GRAIN SIZE DISTRIBUTION

PROJECT TURAP	**DEPTH OF SAMPLE** 2.00 - 2.50 m
LOCATION JL SENTOSA	**DATE OF TESTING** 28/02/08
BOREHOLE NO. HB 2 / **SAMPLE NO.** 1	**TESTED BY** SUNARTO
PROJECT NUMBER: 200802001	



Composition	
Sand	1.5 %
Silt	76.5 %
Clay	22 %

Visual Soil Description	CLAYEY SILT
Soil Classification	UNIFIED SOIL CLASSIFICATION

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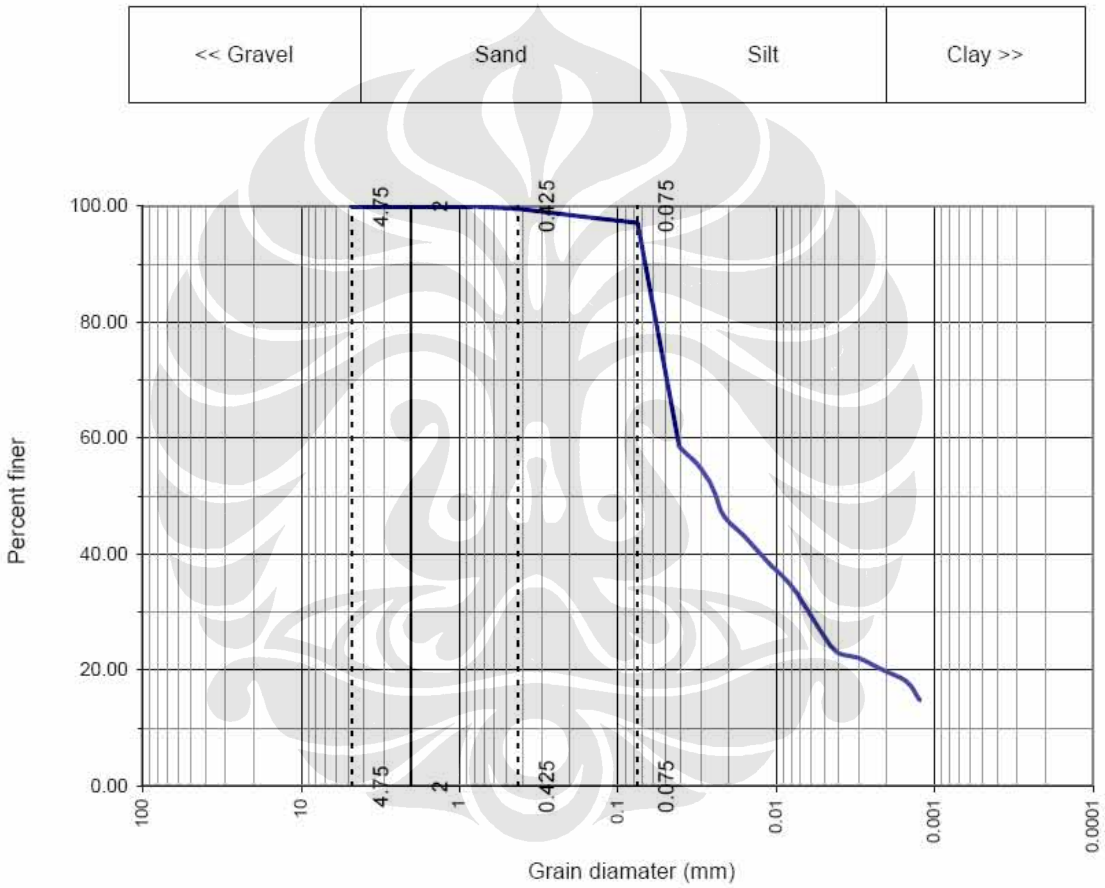
GRAIN SIZE DISTRIBUTION

PROJECT TURAP		**DEPTH OF SAMPLE** 4.00 - 4.50 m
LOCATION JL SENTOSA		**DATE OF TESTING** 28/02/08
BOREHOLE NO. HB 2	**SAMPLE NO.** 2	**TESTED BY** SUNARTO

PROJECT NUMBER: 200802001



Composition	
Sand	3 %
Silt	77 %
Clay	20 %

Visual Soil Description	CLAYEY SILT
Soil Classification	UNIFIED SOIL CLASSIFICATION

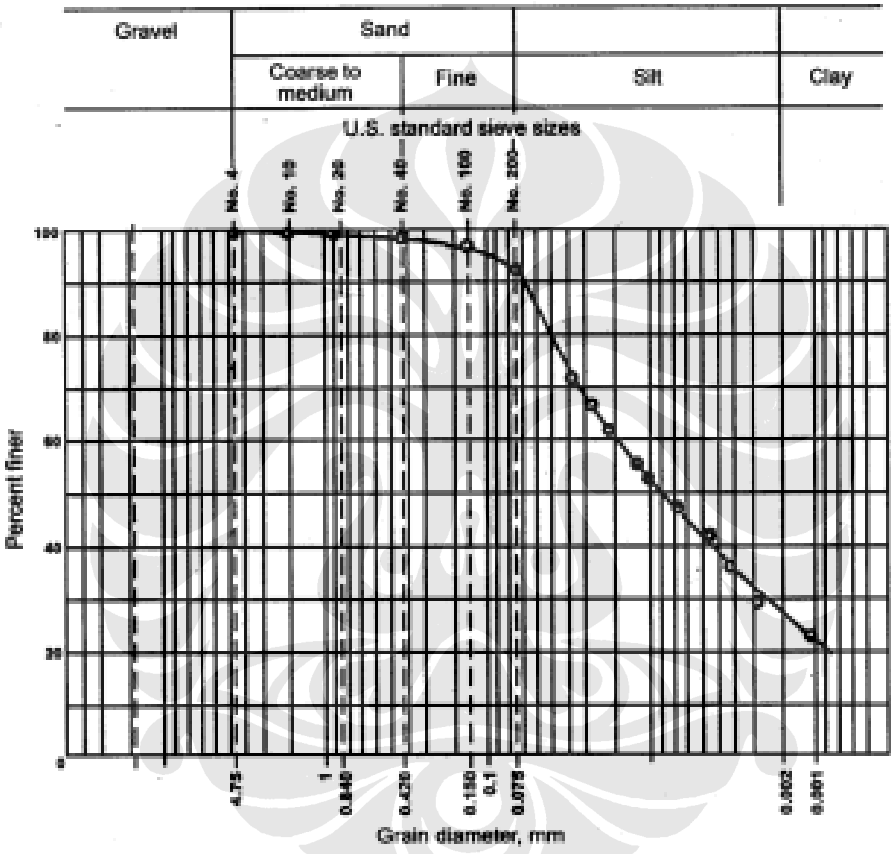
GRAIN SIZE DISTRIBUTION

Project: Depo Kereta api — Job No.: _____

Location of Project: Ratu Jaya Depok — Boring No.: HB 1. — Sample No.: _____

Description of Soil: Clayey Silt — Depth of Sample: 1,50 – 2,00 M.

Tested By: Sunarto — Date of Testing: 7 Mei 2007.



Visual soil description: Clayey Silt

Sand = 8 %, Silt = 64,5 %, Clay = 27,5 %.

Soil classification:

System: Unified of soil classification.

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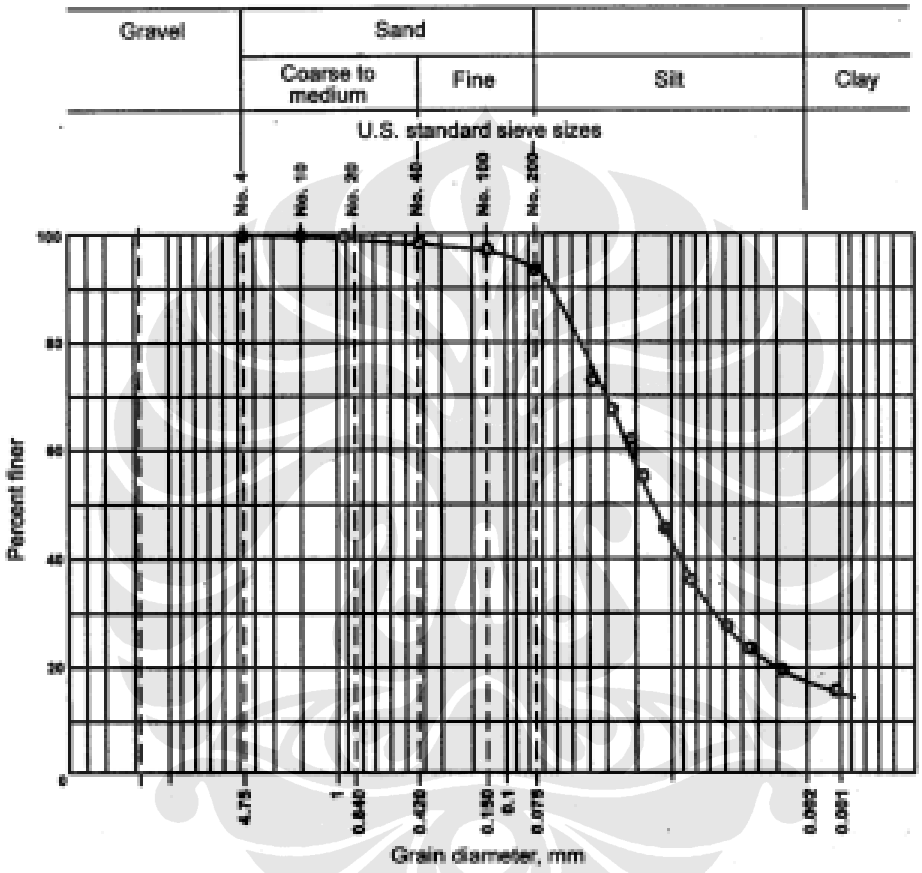
GRAIN SIZE DISTRIBUTION

Project: Depo Kereta api — Job No.: _____

Location of Project: Ratu Jaya Depok — Boring No.: HB 1. — Sample No.: _____

Description of Soil: Clayey Silt — Depth of Sample: 3,00 – 3,50 M.

Tested By: Sunarto — Date of Testing: 7 Mei 2007.



Visual soil description: Clayey Silt

Sand = 7 %, Silt = 75,5 %, Clay = 17,5 %.

Soil classification:

System: Unified of soil classification.

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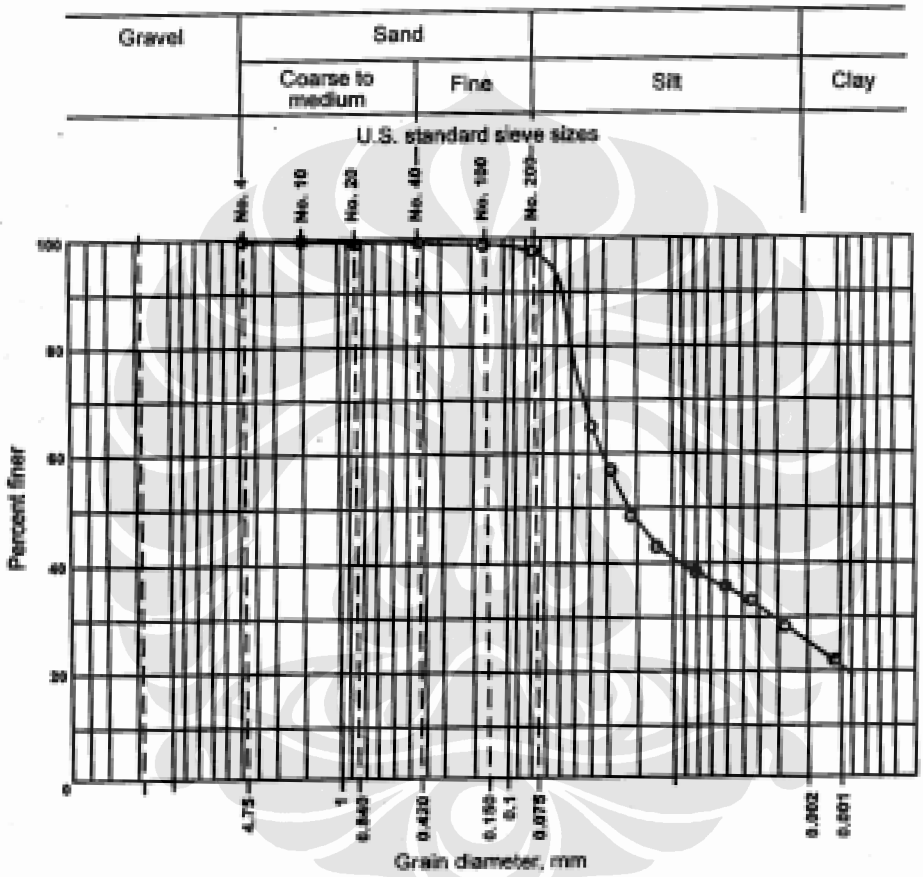
GRAIN SIZE DISTRIBUTION

Project: Depo Kereta api — Job No.: _____

Location of Project: Ratu Jaya Depok — Boring No.: HB 2 — Sample No.: _____

Description of Soil: Clayey Silt — Depth of Sample: 1,00 – 1,50 M.

Tested By: Sunarto — Date of Testing: 7 Mei 2007.



Visual soil description: Clayey Silt
Sand = 2,5 %, Silt = 72,5 %, Clay = 25 %.

Soil classification:

System: Unified of soil classification.

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LABORATORIUM MEKANIKA TANAH
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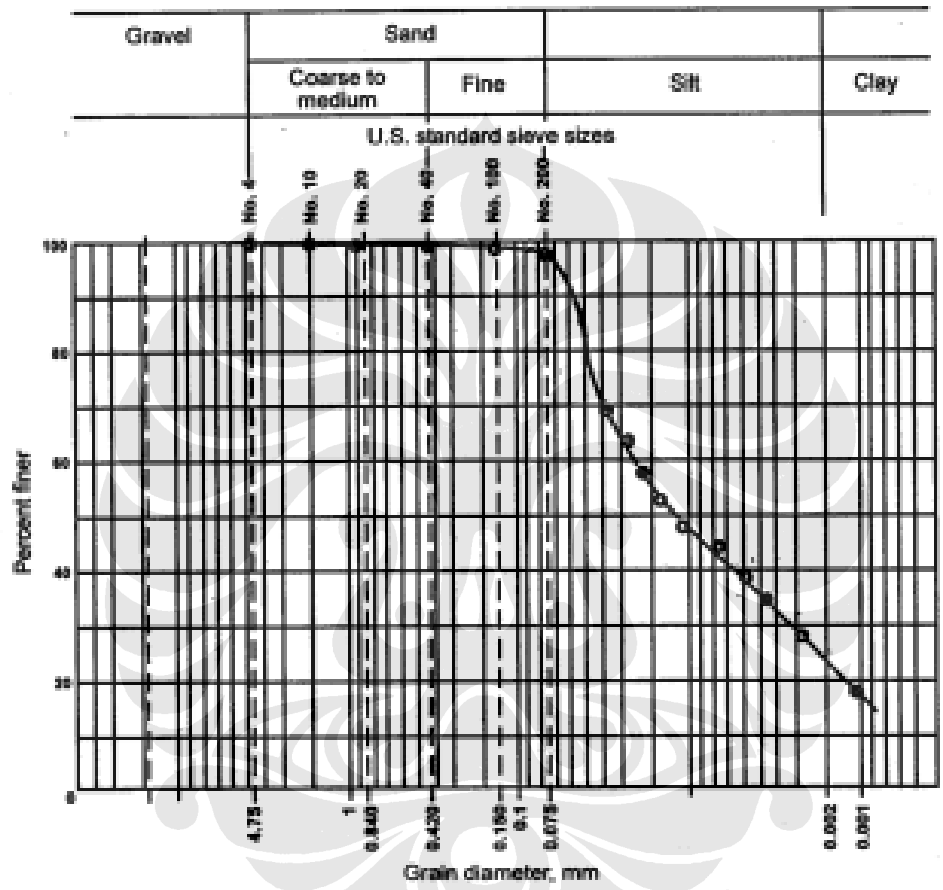
GRAIN SIZE DISTRIBUTION

Project: Depo Kereta api — Job No.: _____

Location of Project: Ratu Jaya Depok — Boring No.: HB 2. — Sample No.: _____

Description of Soil: Clayey Silt — Depth of Sample: 3,00 - 3,50 M.

Tested By: Sunarto — Date of Testing: _____



Visual soil description: Clayey Silt
Sand = 3 %, Silt = 74 %, Clay = 23 %.

Soil classification: _____ System: Unified of soil classification.

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LABORATORIUM MEKANIKA TANAH
Kampus UI - Depok 16424 Telp. (021) 7270029, 78849102 Fax. (021) 7270028

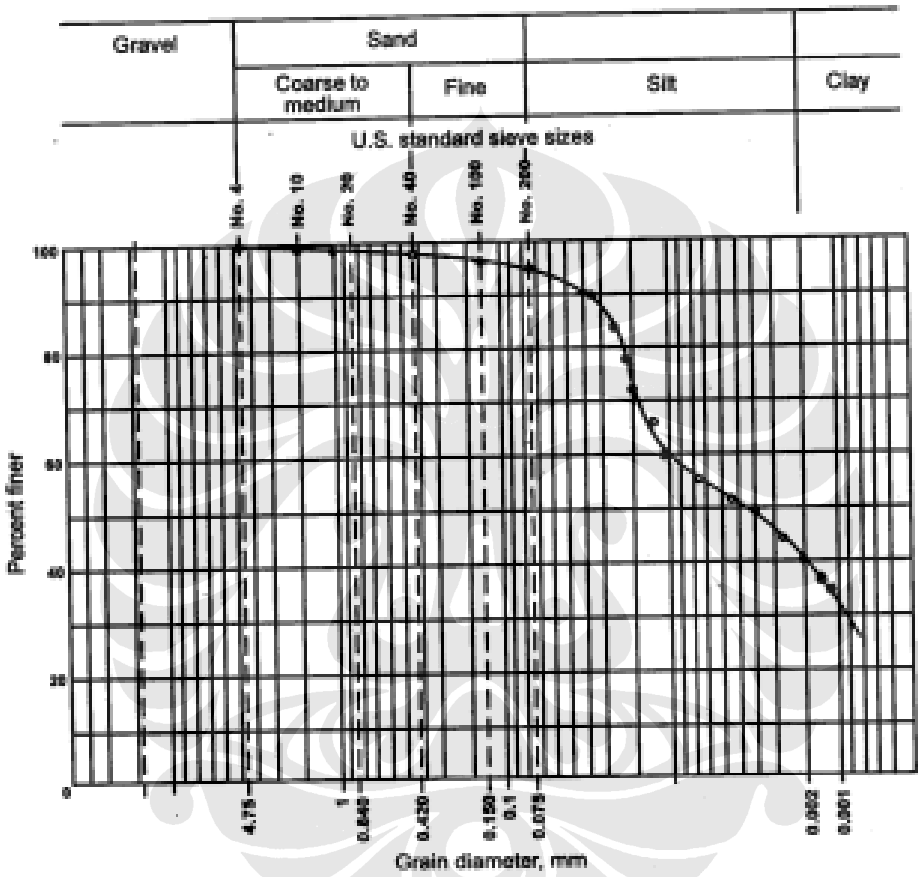
GRAIN SIZE DISTRIBUTION

Project: Depo Kereta Api — Job No.: _____

Location of Project: Ratu Jaya - Depok — Boring No.: HB.3 — Sample No.: 1

Description of Soil: Clayey Silt — Depth of Sample: 1,50 - 2,00 m

Tested By: Wardoyo — Date of Testing: 11 Mei 2007



Visual soil description: Clayey Silt
Sand = 5 % ; Silt = 54 % ; Clay = 41 %

Soil classification: _____ System: Unified Soil Classification

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LABORATORIUM MEKANIKA TANAH
Kampus UI - Depok 16424 Telp. (021) 7270029, 78849102 Fax. (021) 7270028

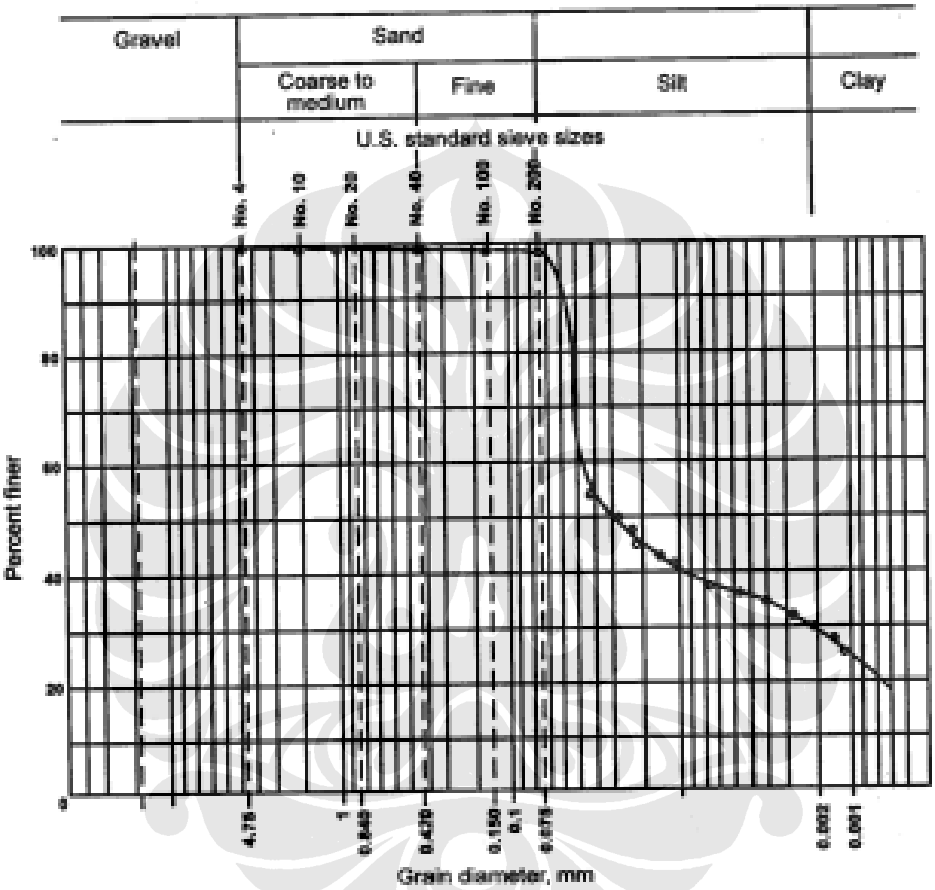
GRAIN SIZE DISTRIBUTION

Project: Depo Kereta Api — Job No.: _____

Location of Project: Ratu Jaya - Depok — Boring No.: HB.3 — Sample No.: 2

Description of Soil: Clayey Silt — Depth of Sample: 3,50 - 4,00 m

Tested By: Wardoyo — Date of Testing: 11 Mei 2007



Visual soil description: Clayey Silt
Sand = 2 % ; Silt = 69 % ; Clay = 29 %

Soil classification:

System: Unified Soil Classification

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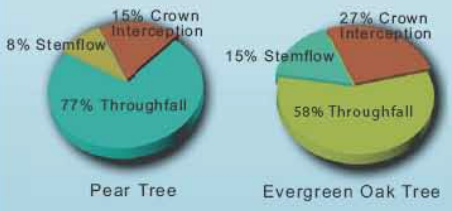
LAMPIRAN 5
BERBAGAI TEKNOLOGI *SOURCE CONTROL* (KONTROL SUMBER) DI DUNIA


STORMWATER
Australia
Belgium
British Columbia
France
Germany
Netherlands
Oregon State
United Kingdom
Washington State
UNITED KINGDOM
"Sustainable Urban Drainage Systems" (SUDS) use "Soakaway" methods such as rock pits, dry wells and infiltration trenches.
400,000 sq.m of permeable paving block designs were sold in 2001. Research is showing that microbes in rock base courses treat oil entering the pavement.
BELGIUM
Some municipalities offer subsidies for source controls; e.g., Mortsel pays $5.60/ sq.m for green roofs and 50% of the cost of an infiltration system.
CURRENT PRACTICE
NETHERLANDS
Infiltration trenches, green roofs and permeable pavement are common. Flood storage on roads is allowed, but not on bikeways!
Dutch wadis are broad vegetated swales that fill with water during heavy rainfalls and then drain in about 24 hours.
FRANCE
Swales ("noues") are valued as visible stormwater treatment. Porous pavements are used both as a source control and to reduce traffic noise.
The grate leads to an underground geo-membrane lined trench filled with sand and pebbles that filters particles and allows infiltration. Excess water flows to further settling and filtration systems.
GERMANY
In use for over 30 years, about 1 in 7 of new flat roofs are green roofs - 13.5 million sq.m in 2001. Most cities reduce stormwater fees when source controls are used.
A swale / trench system reduces stormwater volumes to 1/10th of a conventional system, saving 30% in stormwater fees.
BRITISH COLUMBIA/CANADA
Policies supporting source controls have been in the works since the 1990's. Pilot projects with source controls have been completed and monitoring is on-going. Implementation is accelerating.
Over 600 green roof installations exist in Coastal BC, including this monitored Green Roof at the Vancouver Library.
WASHINGTON
"Low Impact Development" (LID) techniques try to preserve 'natural' watershed characteristics. Stormwater manuals have provided guidance since 1992.
Seattle's "Street Edge Alternatives" (SEA) project captures 98% of the wet season runoff - beautifully.
OREGON
Portland provides "tree credits" in stormwater calculations, and also offers an "eco-roof density bonus" as a green roof incentive.
Buckman Terrace Apartments in Portland uses source controls to avoid runoff into combined sewers.
AUSTRALIA
Australia uses "Water Sensitive Urban Design" (WSUD) to maximize on-site retention, infiltration, treatment and re-use even in clay soils. Aquifer storage and recovery is widely used.
Rainwater reuse on this site reduces the consumption of water from the main system by 77%.
Precedents Around the World
Greater Vancouver Regional District
Stormwater Source Control Design Guidelines 2005
LANARC
kwl
Goya Ngan
Landscape Architect
Detailed design guidelines can be found in the Design Guidelines 2005 report, available at www.gvrd.bc.ca

DESIGN PRINCIPLES

- Maximize the area of absorbent landscape – either existing or constructed – on the site. Conserve as much existing vegetation and undisturbed soil as possible.
- Minimize impervious area by using multi-storey buildings, narrower roads, minimum parking, larger landscape areas, green roof, and pervious paving.
- Disconnect impervious areas from the storm sewer system, having them drain to absorbent landscape.
- Design absorbent landscape areas as dished areas that temporarily store stormwater and allow it to soak in, with overflow for large rain events to the storm drain system.
- Maximize the vegetation canopy cover over the site. Multi-layered evergreens are ideal, but deciduous cover is also beneficial for stormwater management.
- Ensure adequate growing medium depth for both horticultural and stormwater needs – a minimum 150mm for lawn areas, and 450mm depth for shrub/tree areas. In wetter climates with till subsoils, a minimum depth of 300mm for lawn is required to store 60mm of rainfall.
- Cultivate compost into surface soils to create minimum 8% organic matter for lawns, and 15% for planting beds.
- To avoid surface crusting and maintain surface permeability, install vegetative (grass, groundcovers, shrubs, trees) or organic cover (mulch, straw, wood fibre) as early as possible in the construction process, and prior to winter storms.
- Provide effective erosion control during construction, including erosion control on upstream sites that may flow into the absorbent landscape.

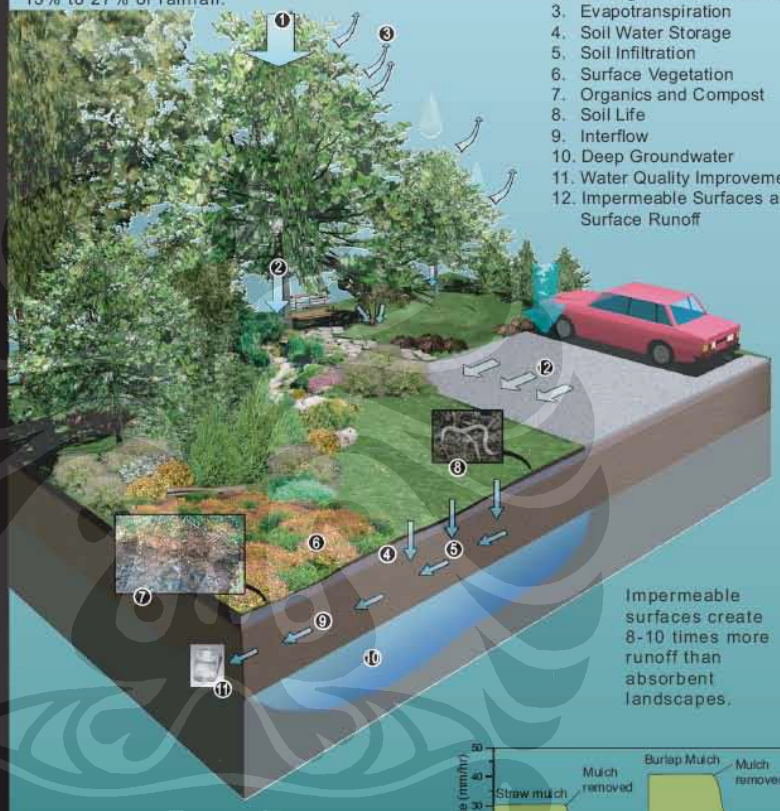


In most natural wooded conditions in the GVRD, 90% of rainfall volume never becomes runoff, but is either soaked into the soils or evaporates / transpirates. Trees, shrubs, grasses, surface organic matter, and soils all play a role.

Variables of **Absorbent Landscape**

1. Crown Interception
2. Throughfall and Stemflow
3. Evapotranspiration
4. Soil Water Storage
5. Soil Infiltration
6. Surface Vegetation
7. Organics and Compost
8. Soil Life
9. Interflow
10. Deep Groundwater
11. Water Quality Improvement
12. Impermeable Surfaces and Surface Runoff

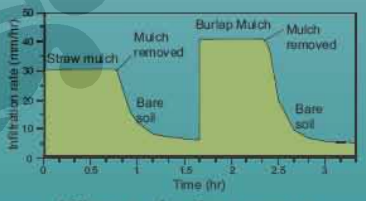
Winter tree canopies intercept 15% to 27% of rainfall.



Impermeable surfaces create 8-10 times more runoff than absorbent landscapes.

Organic matter and soil micro-organisms are vital to maintaining soil infiltration rates.

Rainfall storage in soil is 7% to 18% of soil volume.



Influence of surface cover on infiltration rate of sandy loam

Absorbent Landscapes

Greater Vancouver Regional District

Stormwater Source Control Design Guidelines 2005

LANARC CONSULTANTS LTD

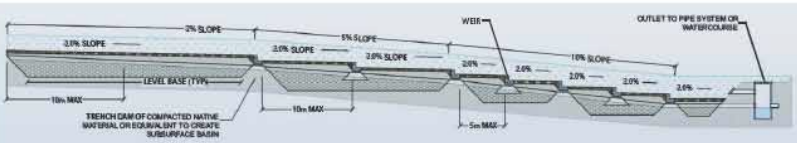
kwl

Goya Ngan Landscape Architect

Detailed design guidelines can be found in the Design Guidelines 2005 report, available at www.gvrd.bc.ca

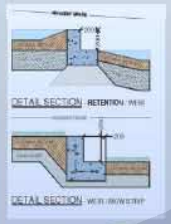
DESIGN PRINCIPLES

- Literature suggests swale areas of about 10-20% of upstream impervious area. For GVRD, calculate swale area by continuous flow modelling.
- Flow to the swale should be distributed sheet flow, travelling through a grassy filter area at the swale verges. Provide pre-treatment and erosion control to avoid sedimentation in the swale.
- Provide a 25mm drop at the edge of paving to the swale soil surface, to allow for positive drainage and buildup of road sanding/organic materials at this edge.
- Swale planting is typically sodded lawn. Low volume swales can be finished with a combination of grasses, shrub, groundcover and tree planting.
- Swale bottom - flat cross section, 600 to 2400mm width, 1-2% longitudinal slope or dished between weirs.
- Swale side slopes - 3(horizontal):1(vertical) maximum, 4:1 preferred for maintenance.
- Weirs to have level top to spread flows and avoid channelization, keyed in 100mm minimum.
- Maximum ponding level - 150mm. Drawdown time for the maximum surface ponded volume - 24 hours.
- Treatment soil depth - 450mm desirable, minimum 150mm if design professional calculates adequate pollutant removal.
- Design stormwater conveyance using Manning's formula or weir equations whichever governs with attention to channel stability during maximum flows.
- Drain rock reservoir and underdrain may be avoided where infiltration tests by a qualified professional, taken at the depth of the proposed infiltration, show an infiltration rate that exceeds the inflow rate.

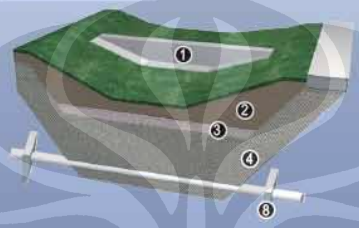


INFILTRATION SWALE

Not To Scale — Longitudinal Profile

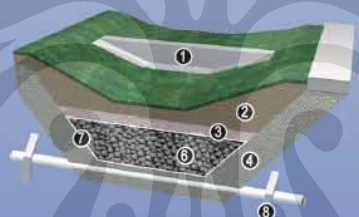


An **Infiltration Swale** is a shallow grassed or vegetated channel designed to capture, detain and treat stormwater and convey larger flows. It takes surface flows from adjacent paved surfaces, holds the water behind weirs, and allows it to infiltrate through a soil bed into underlying soils. The swale and weir structures provide conveyance for larger storm events to the storm drain system. Variations on designs include an underlying drain rock reservoir, with or without a perforated underdrain.



Full Infiltration

Where water entering the swale is filtered through a grass or groundcover layer, and then passes through sandy growing medium and a sand layer into underlying scarified subgrade. Suitable for sites with small catchments and subsoil permeability > 30mm/hr.



Full Infiltration with Reservoir

Designed to reduce surface ponding by providing underground storage in a drain rock reservoir. Suitable for sites with small catchments and subsoil permeability > 15mm/hr.

Partial Infiltration with Reservoir and Subdrain

Where a perforated drain pipe is installed at the top of the reservoir, providing an underground overflow that removes excess water before it backs up to the surface of the swale. Suitable for sites with larger catchments and low infiltration rates into subsoil permeability < 15mm/hr. Provides water quality treatment even if infiltration into subsoils is limited.

1. Weir Keyed into Swale Side Slope
2. Growing Medium (300mm Min.)
3. Sand
4. Existing Scarified Subsoil
5. Perforated Underdrain (150mm Dia. Min.)
6. Drain Rock Reservoir (300mm Min.)
7. Geotextile Along All Sides of Reservoir
8. Trench Dams at All Utility Crossing

Infiltration Swale System

Greater Vancouver Regional District

Stormwater Source Control Design Guidelines 2005

LANARC CONSULTANTS LTD

kwl

Goya Ngan Landscape Architect

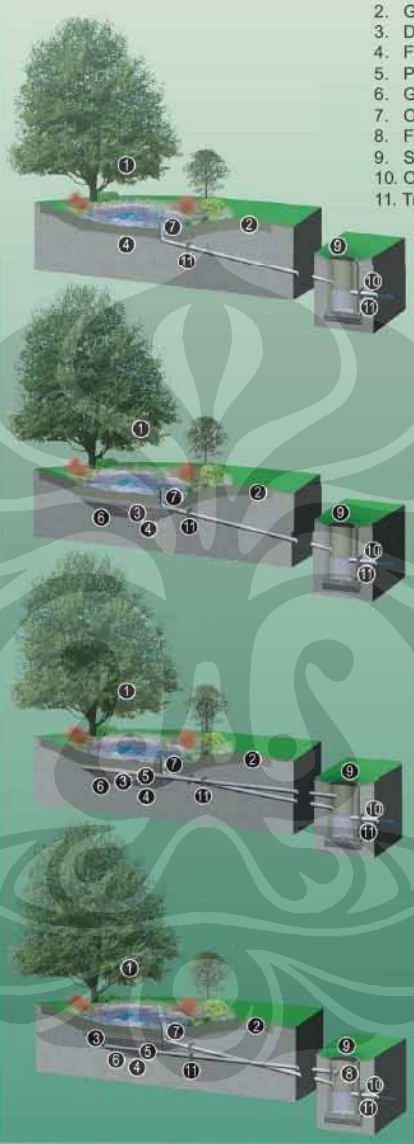
Detailed design guidelines can be found in the Design Guidelines 2005 report, available at www.gvrd.bc.ca

DESIGN PRINCIPLES

- Literature suggests rain garden areas of about 10-20% of upstream impervious area. For GVRD, calculate rain garden area by continuous flow modelling. Optimum rain garden size is about 50sq.m. draining 250sq.m. of impervious area.
- Smaller, distributed rain gardens are better than single large scale facilities.
- Locate rain gardens a minimum 30.5m from wells, 3m downslope of building foundations, and only in areas where foundations have footing drains and are not above steep slopes.
- Provide pretreatment and erosion control i.e. grass filter strip to avoid introducing sediment into the garden.
- At point-source inlets, install non-erodable material, sediment cleanout basins, and weir flow spreaders.
- Bottom width - 600mm (Min.) to 3000mm (desirable). Length-width ratio of 2:1.
- Side slopes - 2:1 maximum, 4:1 preferred for maintenance. Maximum ponded level - 150 - 300mm.
- Draw-down time for maximum ponded volume - 72 hours.
- Treatment soil depth - 450mm (Min.) to 1200mm (desirable); use soils with minimum infiltration rate of 13mm/hr.
- Surface planting should be primarily trees, shrubs, and groundcovers, with planting designs respecting the various soil moisture conditions in the garden. Plantings may include rushes, sedges and grasses as well as lawn areas for erosion control and multiple uses.
- Apply a 50-75mm layer of organic mulch for both erosion control and to maintain infiltration capacity.
- Install a non-erodible outlet or spillway to discharge overflow.
- Avoid utility or other crossings of the rain garden. Where utility trenches must be constructed below the garden, install trench dams to avoid infiltration water following the utility trench.
- Drain rock reservoir and perforated drain pipe may be avoided where infiltration tests by a design professional show a subsoil infiltration rate that exceeds the inflow rate.

An **Infiltration Rain Garden** is a form of bioretention facility designed to have aesthetic appeal as well as a stormwater function. Rain gardens are commonly a concave landscaped area where runoff from roofs or paving infiltrates into deep constructed soils and subsoils below. On subsoils with low infiltration rates, Rain Gardens often have a drain rock reservoir and perforated drain system to convey away excess water.

1. Tree, Shrub and Groundcover Plantings
2. Growing Medium Minimum 450mm Depth
3. Drain Rock Reservoir
4. Flat Subsoil - scarified
5. Perforated Drain Pipe 150mm Dia. Min.
6. Geotextile Along All Sides of Drain Rock Reservoir
7. Overflow (standpipe or swale)
8. Flow Restrictor Assembly
9. Secondary Overflow Inlet at Catch Basin
10. Outflow Pipe to Storm Drain or Swale System
11. Trench Dams at All Utility Crossings



Full Infiltration

Where all inflow is intended to infiltrate into the underlying subsoil. Candidate in sites with subsoil permeability > 30mm/hr. An overflow for large events is provided by pipe or swale to the storm drain system.

Full Infiltration with Reservoir

Adding a drain rock reservoir so that surface water can move quickly through the installed growing medium and infiltrate slowly into subsoils from the reservoir below. Candidate in sites with subsoil permeability > 15mm/hr.

Partial Infiltration

Designed so that most water may infiltrate into the underlying soil while the surplus overflow is drained by perforated pipes that are placed near the top of the drain rock reservoir. Suitable for sites with subsoil permeability > 1 and < 15mm/hr.

Partial Infiltration with Flow Restrictor

For sites with subsoil permeability < 1mm/hr, the addition of a flow restrictor assembly with a small orifice slowly decants the top portion of the reservoir and rain garden. Provides water quality treatment and some infiltration, while acting like a small detention facility.

Rain Garden

Greater Vancouver Regional District

LANARC kwl Goya Ngan Landscape Architect

Detailed design guidelines can be found in the Design Guidelines 2005 report, available at www.gvrd.bc.ca

Stormwater Source Control Design Guidelines 2005

DESIGN PRINCIPLES

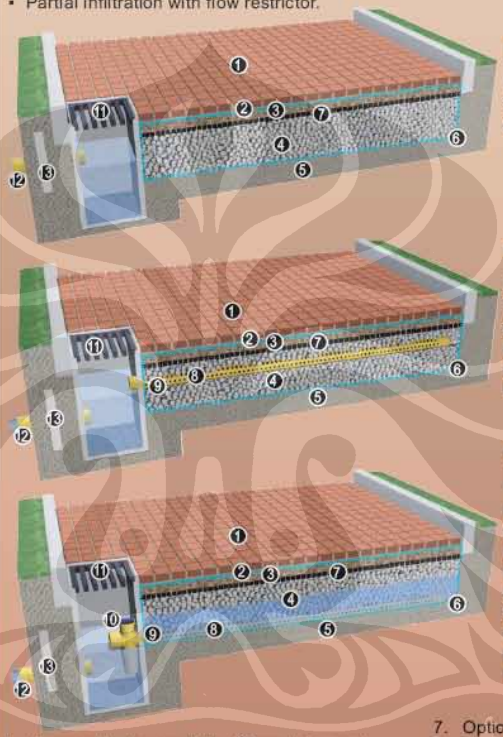
- Pervious paving is most suitable for low traffic areas – driveways, parking areas(maximum 1 - 2 vehicles per day per parking space), walkways, recreational vehicle pads, service roads, fire lanes.
- The ratio of impermeable surface area draining onto pervious pavement area should be 1.2:1 maximum.
- To avoid surface plugging, it is critical to protect pervious paving from sedimentation during and after construction.
- Identify pollutant sources, particularly in industrial/ commercial hotspots, that require pre-treatment or source control upstream.
- For designs which rely entirely on infiltration into underlying soils, the infiltration rate should be 12.5mm/hr minimum.
- Soil subgrade analysis should include soil texture class, moisture content, 96 hour soaked California Bearing Ratio (CBR) and on-site infiltration tests at the elevation of the base of the reservoir.
- Surface slope should be 1% minimum to avoid ponding and related sedimentation of fines.
- Wrap paver bedding material with geotextile filter cloth on bottom and sides to maintain water quality performance and keep out intrusion of fines.
- Provide edge restraint to contain pavers, similar to standard unit paving.
- Design reservoir water levels using continuous flow modelling. Drawdown time - 96 hrs max., 72 hrs desirable.
- Bottom of reservoir: flat in full infiltration designs, minimum 0.1% slope to drain in piped systems.
- Where utility trenches must be constructed below the reservoir, install trench dams at exits to avoid infiltration water following the utility trench.
- Pavers with wide joints should not be used for disabled persons parking or pedestrian ramps at street crossings.
- If being designed for heavy loads, optional reinforcing grids may be included in the pavement subbase.

Pervious paving is a surface layer that allows rainfall to percolate into an underlying reservoir base where rainfall is either infiltrated to underlying soils or removed by a subsurface drain. The surface component of pervious paving can be:

- Porous asphalt or porous concrete.
- Concrete or plastic grid structures filled with unvegetated gravel or vegetated soil,
- Concrete modular pavers with gapped joints that allow water to percolate through.

Pervious pavement designs may be one of three types:

- Full infiltration.
- Partial infiltration.
- Partial infiltration with flow restrictor.



Full Infiltration

Where rainfall is intended to infiltrate into the underlying subsoil. Candidate in sites with subsoil permeability > 15mm/hr.

Partial Infiltration

Designed so that most water may infiltrate into the underlying soil while the surplus overflow is drained by perforated pipes that are placed near the top of the drain rock reservoir. Suitable for subsoil permeability >1 and < 15mm/hr.

Partial Infiltration with Flow Restrictor

Where subsoil permeability is < 1mm/hr, water is removed at a controlled rate through a bottom pipe system and flow restrictor assembly. Systems are essentially underground detention systems, used where the underlying soil has very low permeability or in areas with high water table. Also provides water quality benefits.

1. Permeable Pavers (Min. 80mm thickness)
2. Aggregate Bedding Course - not sand (50mm depth)
3. Open Graded Base (depth varies by design application)
4. Open Graded Sub-base (depth varies by design application)
5. Subsoil - flat and scarified in infiltration designs
6. Geotextile on All Sides of Reservoir
7. Optional Reinforcing Grid for Heavy Loads
8. Perforated Drain Pipe 150mm Dia. Min.
9. Geotextile Adhered to Drain at Opening
10. Flow Restrictor Assembly
11. Secondary Overflow Inlet at Catch Basin
12. Outlet Pipe to Storm Drain or Swale System. Locate Crown of Pipe Below Open Graded Base (no. 3) to Prevent Heaving During Freeze/Thaw Cycle
13. Trench Dams at All Utility Crossings

Pervious Paving

Greater Vancouver Regional District

LANARC CONSULTANTS LTD kwl Goya Ngan Landscape Architect

Detailed design guidelines can be found in the Design Guidelines 2005 report, available at www.gvrd.bc.ca

Stormwater Source Control Design Guidelines 2005

DESIGN PRINCIPLES

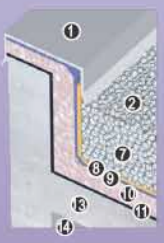
- Suitable for flat roofs and, with proper design, roofs of 20° (4:12 roof pitch) or less.
- Suitable for many rooftop situations – industrial, warehousing, commercial buildings, office complexes, hospitals, schools, institutional/ administrative buildings, residential and garages.
- Design a green roof at the same time as designing the building or retrofit, so that the structural load can be balanced with the design of the building.
- In calculating structural loads, always design for the saturated weight of each material.
- Provide construction and maintenance access to extensive green roofs. Access through a 'man door' is preferable to a roof hatch.
- Roofs with less than 2% slope require special drainage construction so that no part of the growing medium is continuously saturated.
- Avoid monocultures when planting a green roof; the success of establishing a self-maintaining plant community is increased when a mix of species is used.
- Provide intensive maintenance for the first 2 years after plant installation – irrigation in dry periods, weed removal, light fertilization with slow release complete fertilizers, and replacement of dead plants.
- To facilitate access and prevent moisture on exposed structural components, provide plant free zones along the perimeter, adjacent facades, expansion joints, and around each roof penetration.
- Fire breaks of non-combustible material, 50cm wide, should be located every 40m in all directions and at roof penetrations.
- Provide protection against root penetration of the waterproof membrane by either adding a root barrier or using a membrane that is itself resistant to root penetration.

A **Green Roof** is a roof with a veneer of drainage and growing media that supports living vegetation. Green roofs provide a wide range of benefits – from reduction in peak flows and volumes to building heat gain reductions. There are two basic types:

- Intensive – deeper growing medium to support larger plants and trees; designed for public use as well as stormwater and insulation functions.
- Extensive - shallow, lightweight growing medium; designed for stormwater, insulation and environmental functions; vegetation is low and hardy; usually no public access.

Extensive Green Roof

1. Wall Cap Flashing, waterproof membrane extends to 100mm above finished grade
2. Drain Rock, Paving Slab, or Other Buffer Equivalent
3. Wood, Steel or Concrete Curb/Edging (Optional)
4. Planting
5. Growing Medium
6. Filter Layer
7. Drainage Layer
8. Protection Layer and Root Barrier
9. Waterproof Membrane
10. Thermal Insulation
11. Vapour Barrier
12. Area Drain
13. Structural Slab
14. Building Interior
15. Wall Flashing, waterproof membrane extends to 150mm above finished grade



Green Roof

Greater Vancouver Regional District

Stormwater Source Control Design Guidelines 2005

LANARC CONSULTANTS LTD. kwl Goya Ngan Landscape Architect

Detailed design guidelines can be found in the Design Guidelines 2005 report, available at www.gvrd.bc.ca

DESIGN PRINCIPLES

■ Infiltration Trench System:

a) Locate infiltration trench at least 3m from any building, 1.5m from property lines, and 6m from adjacent infiltration facilities (or as recommended by a geotechnical engineer).

b) Sump: Provide a lid for periodic inspection and cleanout. Include a T-inlet pipe to trap oils, sediments and debris.

c) Infiltration Trench: installation of distribution pipe and bottom of drainrock to be level. If more than one section of infiltration trench is required, design so that underground water is temporarily 'ponded' in each infiltration section.

d) Install the Infiltration Trench in native ground, and avoid over-compaction of the trench sides and bottom, which reduces infiltration.

e) Observation well for each infiltration trench (optional): vertical standpipe, with perforated sides, and locking lid, to allow the monitoring of water depth.

■ Soakaway Manholes System:

a) Provide a report from an engineer with experience in geotechnical engineering including on-site test data of infiltration rates at the depth of the proposed infiltration. The bottom of the shaft shall be at least 600mm above the seasonal high water table or bedrock, or as recommended by the engineer.

b) If steep slopes or drinking water wells exist within 200m horizontally from the proposed Soakaway Manhole, provide a hydro-geotechnical report to analyze site-specific risks and determine setbacks.

c) Provide a sedimentation manhole, and a maximum of two Soakaway Manholes in series, unless otherwise approved.

d) Provide an overflow from the Soakaway Manhole to the storm drainage system or major storm flow path.

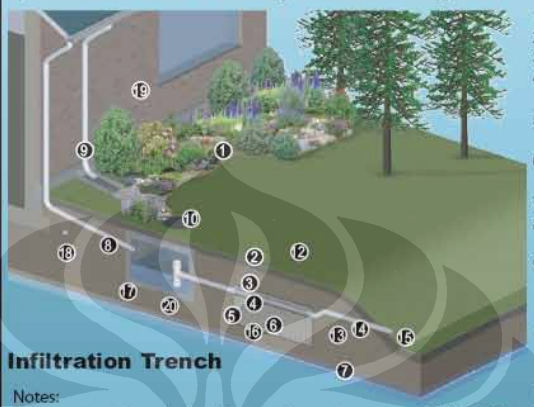
An **Infiltration Trench** System includes an inlet pipe or water source, catch basin sump, perforated distribution pipe, infiltration trench and overflow to the storm drainage system.

A Soakaway Manhole (Sump, or Dry Well) System includes an inlet pipe, a sedimentation manhole, and one or more infiltration shafts with connecting pipes. Use of Infiltration Shaft will be limited by hydro-geotechnical conditions in much of GVRD.

Limitations of Infiltration Trench or Soakaway Manholes:

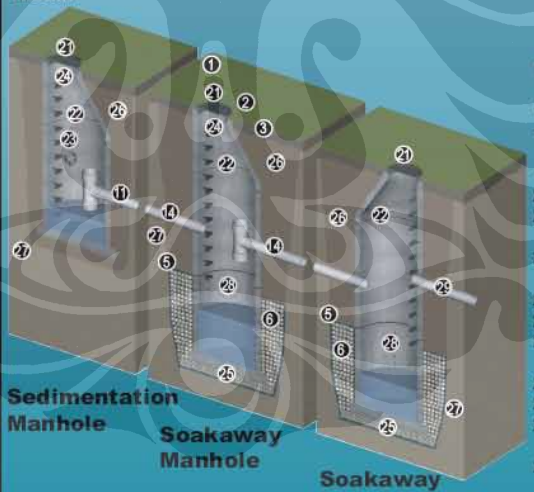
a) To avoid groundwater pollution, do not direct un-treated polluted runoff to Infiltration Trench or Shaft:
- Direct clean runoff (roof, non-automobile paving) to Infiltration Trench or Shaft.
- For polluted runoff (roads > 1000 vehicles / day, parking areas, other pollution sources), provide upstream source control for pollutant reduction prior to release to Infiltration Trench or Shaft.

b) Use infiltration trench or shaft only in areas with footing drains.



Infiltration Trench

Notes:
All precast sections shall conform to the requirements of ASTM C 478.
Provide a min. of 150mm of 25mm or 19mm clean crushed rock under all pipes.
Invert shall be level and smooth.
Soakaway Manhole barrel shall not be perforated within 1200mm of the cone.



Sedimentation Manhole **Soakaway Manhole** **Soakaway Manhole**

1. Grass or Other Planting
2. Finish Grade
3. Growing Medium Backfill
4. 100mm Dia PVC DR28 Perforated Pipe
5. Light Non-woven Polyester Geotextile c/w Min. 400mm Laps
6. 50mm Drain Rock or Rock of Equal Porosity
7. Maximum Groundwater Elevation
8. Non-polluted Drainage From Building or Terrace
9. Alternate Surface Route - With Splash Pad and Vegetated Swale to CB
10. CB Lid / Access Hatch for Cleanout, Inspection and Inflow / Overflow from Sump
11. Solid Pipe c/w Inlet Tee
12. Observation Well (Optional)
13. Provide pipe elbows to have outlet pipe invert at top of infiltration pipe
14. PVC Solid Pipe
15. Discharge to Storm Drainage System. Ensure Drainage Does Not Impact Neighbouring Uses. Direct Discharge to Road Right-of-way if Necessary
16. Infiltration Trench with Level Bottom
17. Catch Basin
18. Building Footing Drain (Not Connected to Infiltration Facility)
19. Building
20. 50mm Dia Drain Hole
21. Standard Manhole Frame and Cover
22. Seal Joints with Cement Grout or Approved Mastic
23. Street Inlet Connection
24. Ladder Rung
25. 25mm Crush Gravel or Drain Rock Base
26. Native Soil Back Fill
27. Undisturbed Ground
28. 1200mm Perforated Barrel (Langley Concrete or Equal)
29. Overflow to storm drainage system.

Infiltration Trench & Soakaways

Greater Vancouver Regional District

Stormwater Source Control Design Guidelines 2005

LANARC Consultants Ltd. kwl Goya Ngan Landscape Architect

Detailed design guidelines can be found in the Design Guidelines 2005 report, available at www.gvrd.bc.ca

LAMPIRAN 6
TIERED ACCESS PROTOCOL UNTUK *'WATER BALANCE MODEL POWERED BY QUALHYMO'*

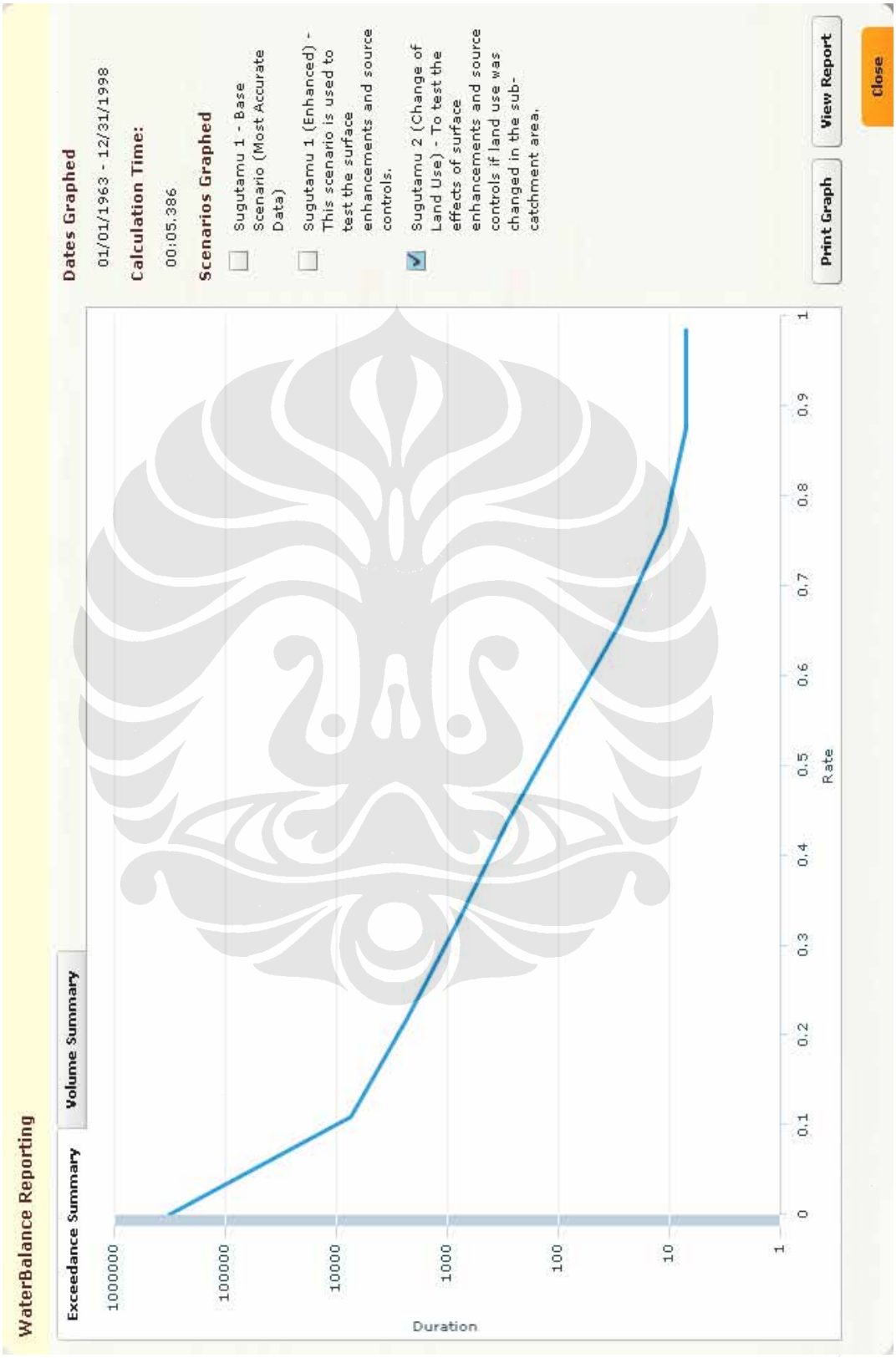
WATER Balance MODEL Powered By QUALHYMO

Tiered Access Protocol

	Project Partner	Paying Subscriber	General User
GENERAL DESCRIPTION	▪ Defined as a local government that has been designated as a Partner by the relevant provincial steering committee ▪ Password-protected access ▪ **Total** flexibility to customize soils and land use database ▪ May assign access on a time-limited basis to consultants and/or others for specific projects	▪ Defined as any agency, company, group or individual that pays a renewable annual 'fee for service' to have more options than a General User ▪ Password-protected access ▪ **Some** flexibility to customize values for input parameters ▪ Cannot modify municipal land use databases	▪ Defined as anybody in the world with Internet access ▪ Includes employees of senior government agencies, unless involved with a specific project or Local Government Partner ▪ **No** flexibility to customize values for input parameters ▪ Restricted to default values only
Annual Fee	Yes	Yes	None
Governance	Yes – provincial steering committee only	None	None
Post News Items	Yes – provincial homepage only	No	No
Create Projects	Yes	Yes	Yes
Save Data	Yes	Yes – but only for subscription period	For 7 days only
Load Climate Data	Yes – fee for service; partner province responsible for QA/QC; shared use by all Partners	Yes – fee for service; QA/QC by Subscriber	No
Set Targets	Yes	Yes	No
View Results	Yes	Yes	Yes
SOILS			
- Add a Soil Type	Yes	Yes	No
- Save a Soil Type	Yes, and shared use by all Partners	Yes, but cannot be used by others	No
LAND USE			
- Add a Land Use	Yes	Yes	No
- Save a Land Use	Yes, and shared use by all Partners	Yes, but cannot be used by others	No
SURFACE CONDITIONS			
- Add a Surface Condition	Yes	Yes	No
- Save a Surface Condition	Yes, and shared use by all Partners	Yes, but cannot be used by others	No
CAPABILITIES			
- Model Site Surface Alteration	Yes	Yes	Yes
- Model Site Controls with Baseflow	Yes	Yes	Yes
- Model Detention Pond Storage	Yes	Yes	No
- Model Stream Erosion	Yes	Yes	Yes
- Model Watershed c/w 2 catchments	Yes	Yes	No

DATE OF THIS VERSION: March 2008

LAMPIRAN 7
HASIL PENGUJIAN '*WATER BALANCE MODEL*' PADA *SUB-CATCHMENT* YANG DITINJAU – SUGUTAMU 1: TANPA *SOURCE CONTROL*


WaterBalance Reporting
Exceedance Summary
Volume Summary
Dates Graphed
01/01/1963 - 12/31/1998
Calculation Time:
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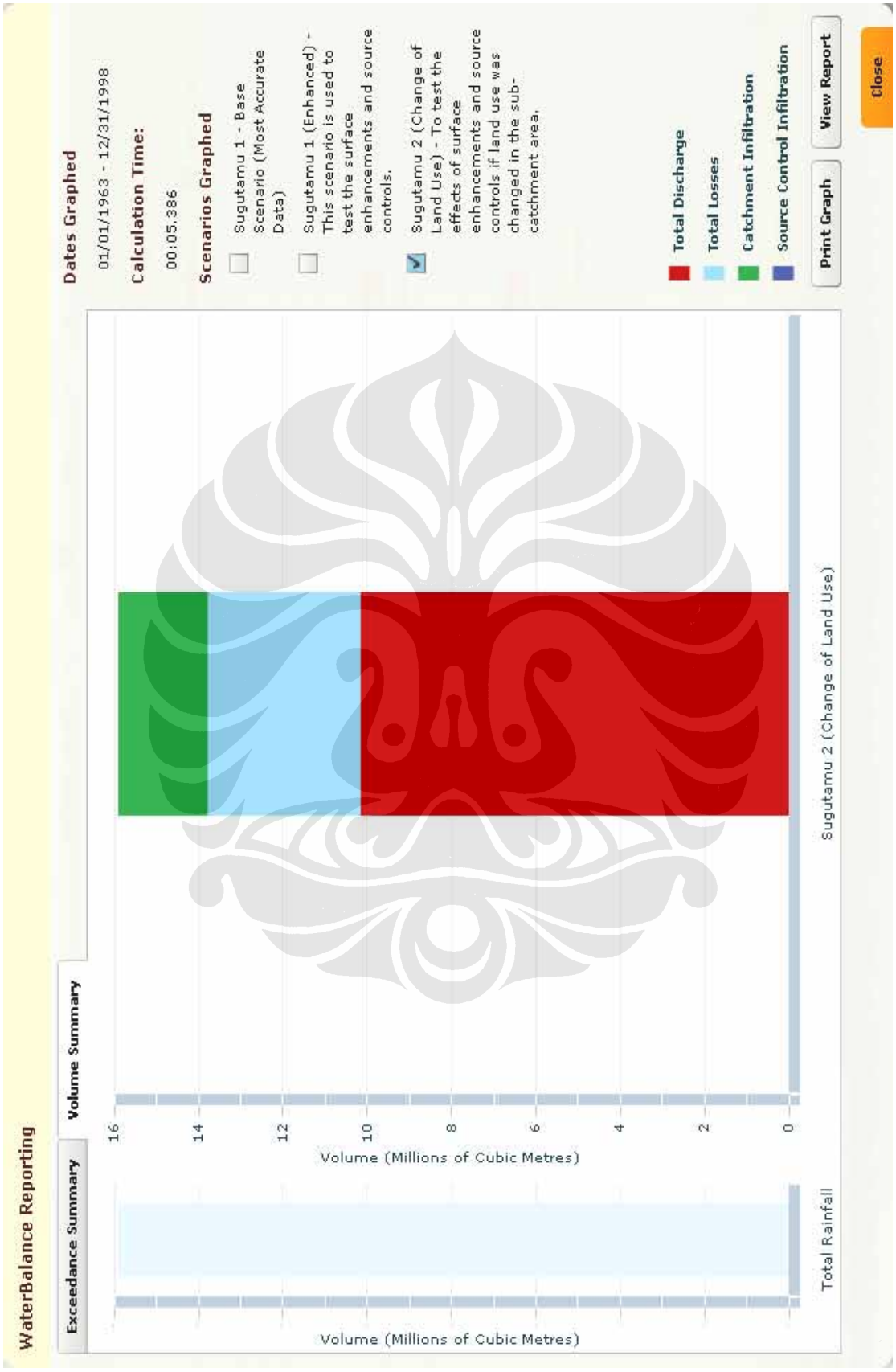
Scenarios Graphed
Sugutamu 1 - Base Scenario (Most Accurate Data)
Sugutamu 1 (Enhanced) - This scenario is used to test the surface enhancements and source controls.
Sugutamu 2 (Change of Land Use) - To test the effects of surface enhancements and source controls if land use was changed in the sub-catchment area.
Print Graph
View Report
Close
Duration
Rate
1000000
100000
10000
1000
100
10
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


WaterBalance Reporting
Exceedance Summary
Volume Summary
Dates Graphed
01/01/1963 - 12/31/1998
Calculation Time:
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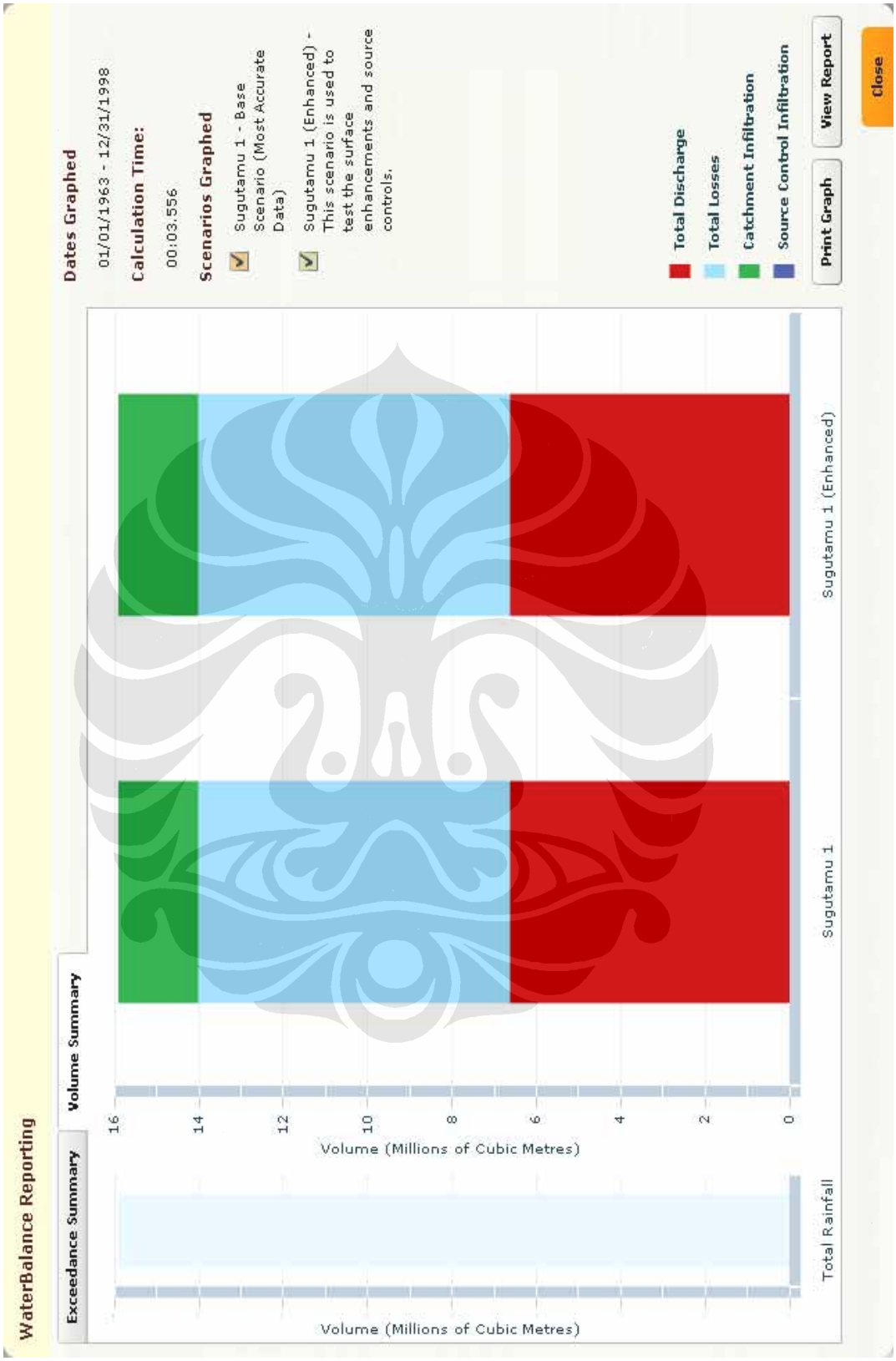
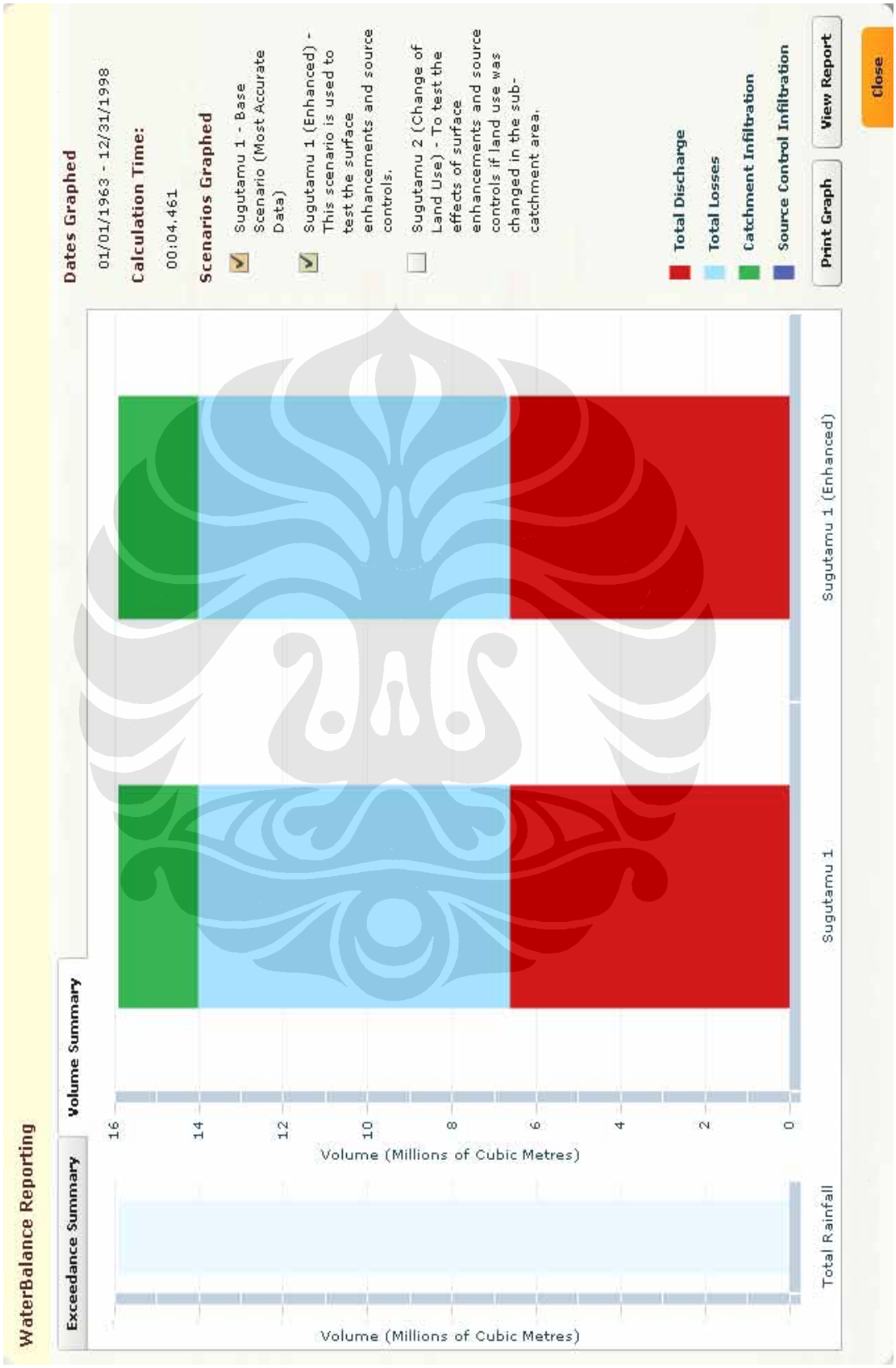
Scenarios Graphed
Sugutamu 1 - Base Scenario (Most Accurate Data)
Sugutamu 1 (Enhanced) - This scenario is used to test the surface enhancements and source controls.
Sugutamu 2 (Change of Land Use) - To test the effects of surface enhancements and source controls if land use was changed in the sub-catchment area.
Total Discharge
Total Losses
Catchment Infiltration
Source Control Infiltration
Print Graph
View Report
Close
16
14
12
10
8
6
4
2
0
Volume (Millions of Cubic Metres)
Sugutamu 2 (Change of Land Use)
Total Rainfall
Volume (Millions of Cubic Metres)

LAMPIRAN 8
HASIL PENGUJIAN '*WATER BALANCE MODEL*' PADA *SUB-CATCHMENT* YANG DITINJAU – SUGUTAMU 1: PERBANDINGAN ANTARA TIDAK MENGUNAKAN *SOURCE CONTROL* DENGAN MENGGUNAKAN 1 (SATU) *SOURCE CONTROL*



LAMPIRAN 9
HASIL PENGUJIAN *'WATER BALANCE MODEL'* PADA *SUB-CATCHMENT* YANG DITINJAU – SUGUTAMU 1: PERBANDINGAN ANTARA TIDAK MENGUNAKAN *SOURCE CONTROL* DENGAN MENGGUNAKAN 5 (LIMA) *SOURCE CONTROL*


WaterBalance Reporting
Exceedance Summary
Volume Summary
Dates Graphed
01/01/1963 - 12/31/1998
Calculation Time:
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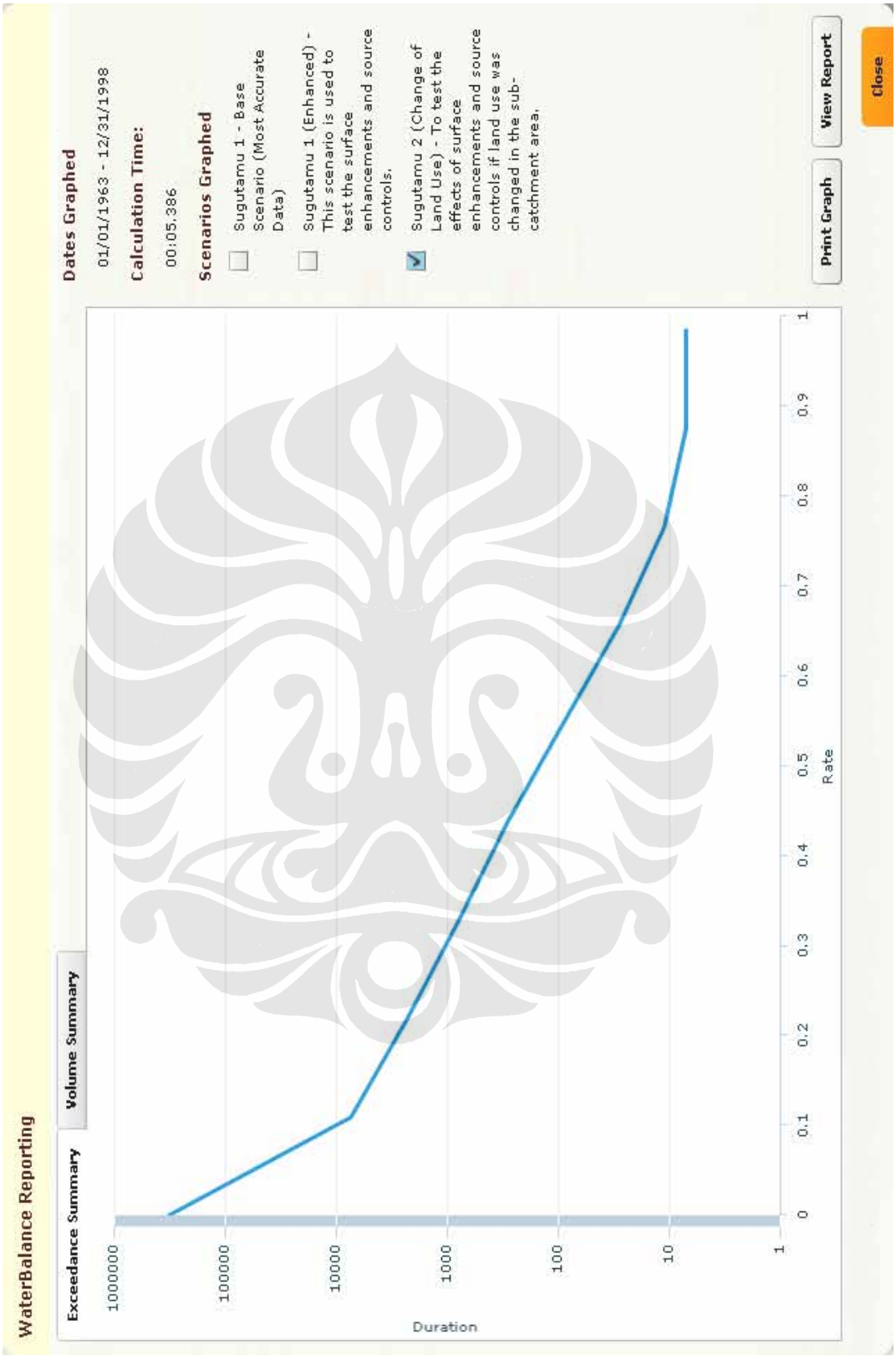
Scenarios Graphed
Sugutamu 1 - Base Scenario (Most Accurate Data)
Sugutamu 1 (Enhanced) - This scenario is used to test the surface enhancements and source controls.
Sugutamu 2 (Change of Land Use) - To test the effects of surface enhancements and source controls if land use was changed in the sub-catchment area.
Total Discharge
Total Losses
Catchment Infiltration
Source Control Infiltration
Print Graph
View Report
Close
16
14
12
10
8
6
4
2
0
Volume (Millions of Cubic Metres)
Sugutamu 1
Sugutamu 1 (Enhanced)
Total Rainfall
Volume (Millions of Cubic Metres)

LAMPIRAN 10
HASIL PENGUJIAN *'WATER BALANCE MODEL'* PADA *SUB-CATCHMENT* YANG DITINJAU – SUGUTAMU 2: PENGUBAHAN PENGGUNAAN LAHAN TANPA *SOURCE CONTROL*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Exceedance Summary
Volume Summary
Dates Graphed
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Calculation Time:
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Scenarios Graphed
Sugutamu 1 - Base Scenario (Most Accurate Data)
Sugutamu 1 (Enhanced) - This scenario is used to test the surface enhancements and source controls.
Sugutamu 2 (Change of Land Use) - To test the effects of surface enhancements and source controls if land use was changed in the sub-catchment area.
Print Graph
View Report
close
1000000
100000
10000
1000
100
10
1
Duration
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0.3
0.4
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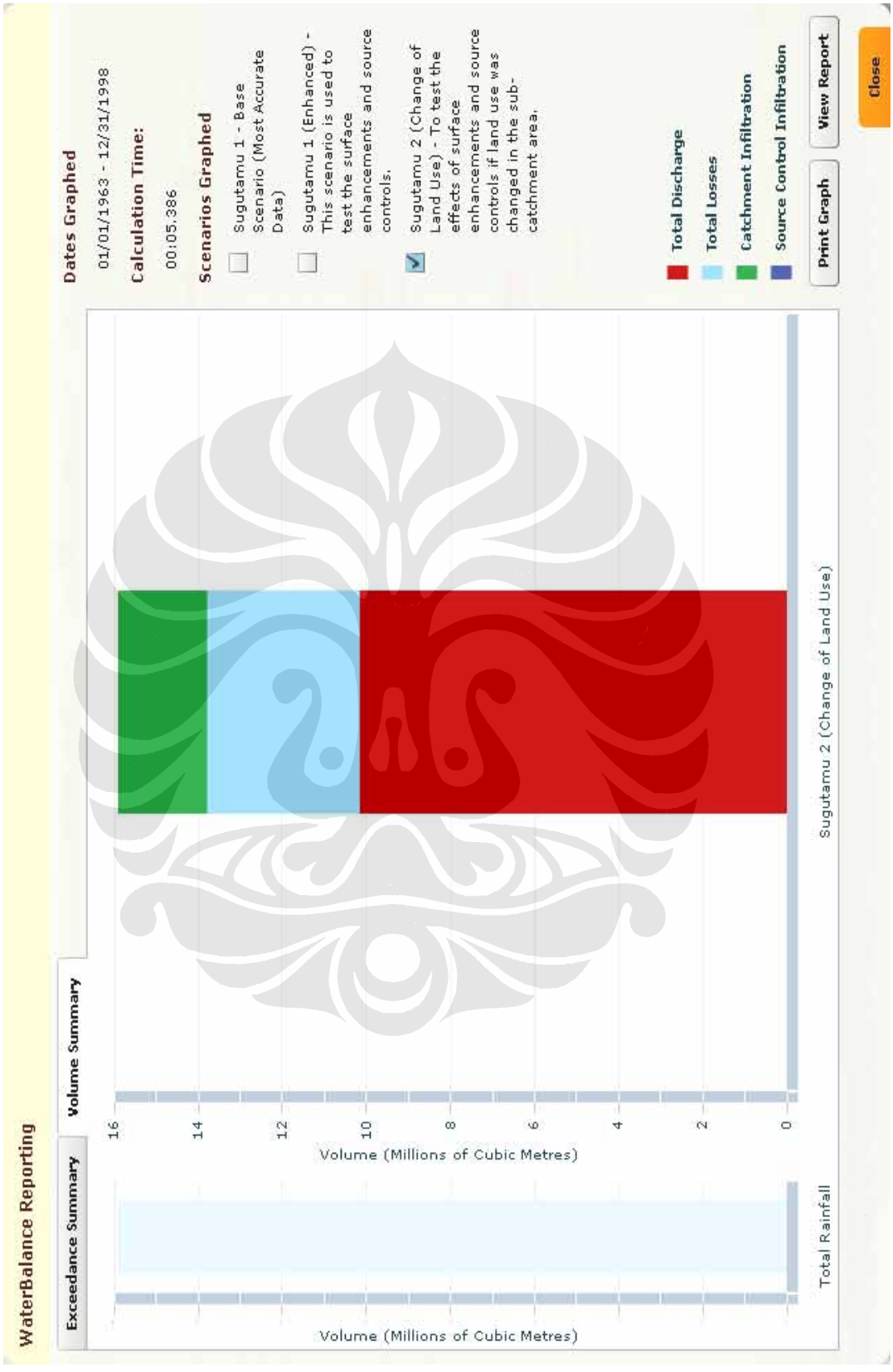
0.8
0.9
1
Rate


WaterBalance Reporting
Exceedance Summary
Volume Summary
Dates Graphed
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Calculation Time:
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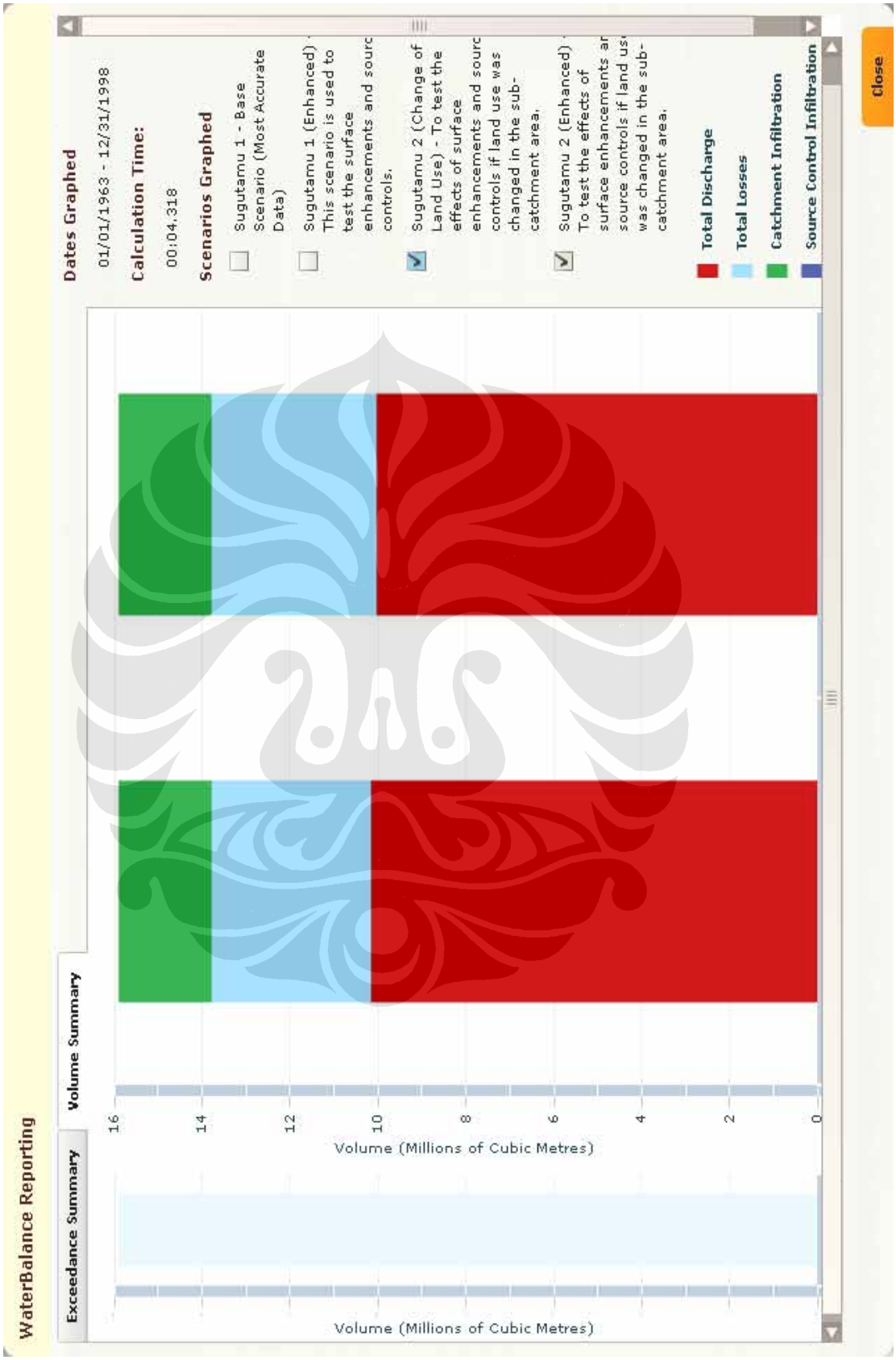
Scenarios Graphed
Sugutamu 1 - Base Scenario (Most Accurate Data)
Sugutamu 1 (Enhanced) - This scenario is used to test the surface enhancements and source controls.
Sugutamu 2 (Change of Land Use) - To test the effects of surface enhancements and source controls if land use was changed in the sub-catchment area.
Total Discharge
Total Losses
Catchment Infiltration
Source Control Infiltration
Print Graph
View Report
Close
16
14
12
10
8
6
4
2
0
Volume (Millions of Cubic Metres)
Sugutamu 2 (Change of Land Use)
Total Rainfall
Volume (Millions of Cubic Metres)

LAMPIRAN 11
HASIL PENGUJIAN *'WATER BALANCE MODEL'* PADA *SUB-CATCHMENT* YANG DITINJAU – SUGUTAMU 2: PERBANDINGAN ANTARA TIDAK MENGUNAKAN *SOURCE CONTROL* DENGAN MENGGUNAKAN 5 (LIMA) *SOURCE CONTROL*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Volume Summary
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Scenarios Graphed
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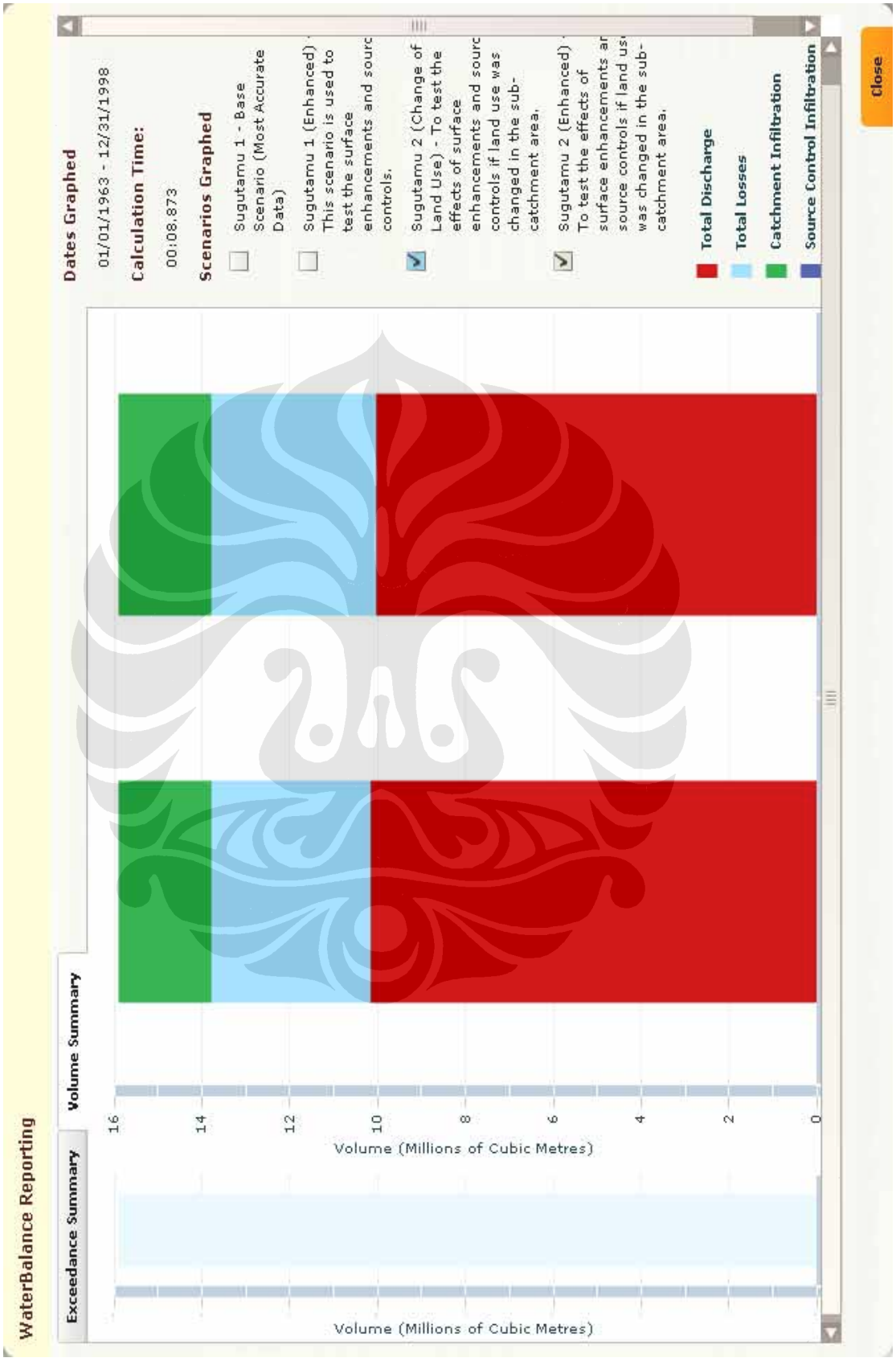
Sugutamu 1 (Enhanced) - This scenario is used to test the surface enhancements and sourc controls.
Sugutamu 2 (Change of Land Use) - To test the effects of surface enhancements and sourc controls if land use was changed in the sub-catchment area.
Sugutamu 2 (Enhanced) - To test the effects of surface enhancements ar source controls if land us was changed in the sub-catchment area.
Total Discharge
Total Losses
Catchment Infiltration
Source Control Infiltration
Close
16
14
12
10
8
6
4
2
0
Volume (Millions of Cubic Metres)
Volume (Millions of Cubic Metres)

LAMPIRAN 12
HASIL PENGUJIAN *'WATER BALANCE MODEL'* PADA *SUB-CATCHMENT* YANG DITINJAU – SUGUTAMU 2: PERBANDINGAN ANTARA TIDAK MENGUNAKAN *SOURCE CONTROL* DENGAN MENGGUNAKAN 10 (SEPULUH) *SOURCE CONTROL*

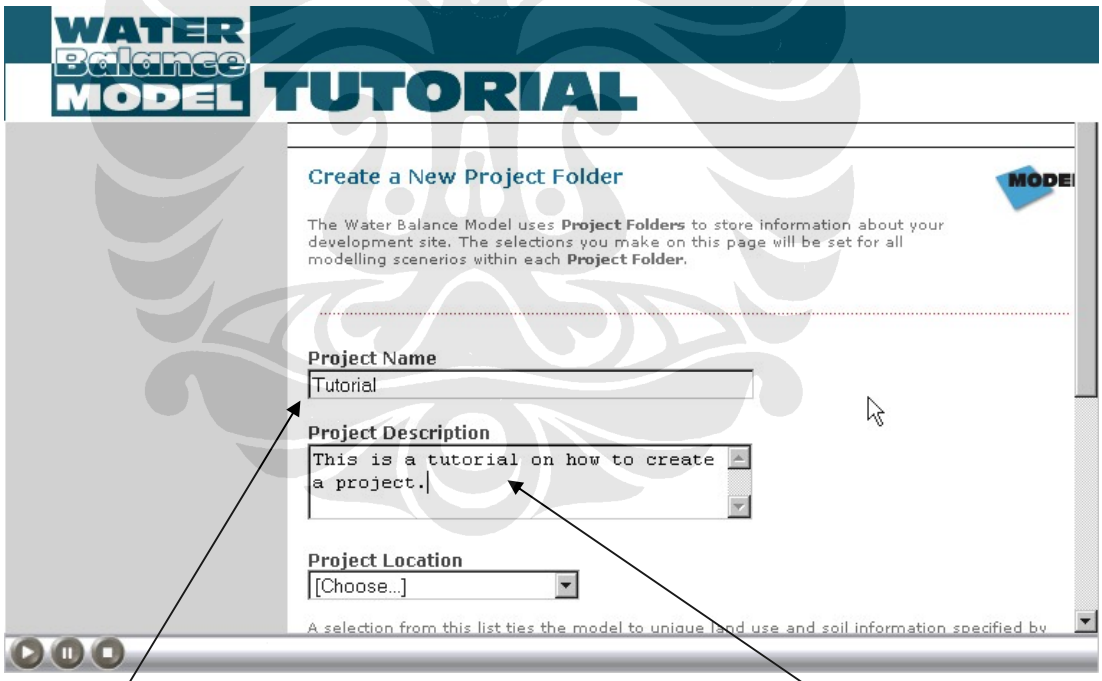

WaterBalance Reporting
Volume Summary
Exceedance Summary
Dates Graphed
01/01/1963 - 12/31/1998
Calculation Time:
00:08.873
Scenarios Graphed
Sugutamu 1 - Base Scenario (Most Accurate Data)
Sugutamu 1 (Enhanced) - This scenario is used to test the surface enhancements and sourc controls.
Sugutamu 2 (Change of Land Use) - To test the effects of surface enhancements and sourc controls if land use was changed in the sub-catchment area.
Sugutamu 2 (Enhanced) - To test the effects of surface enhancements ar source controls if land us was changed in the sub-catchment area.
Total Discharge
Total Losses
Catchment Infiltration
Source Control Infiltration
Close
16
14
12
10
8
6
4
2
0
Volume (Millions of Cubic Metres)
Volume (Millions of Cubic Metres)

LAMPIRAN 13
TUTORIAL PENGGUNAAN *'WATER BALANCE MODEL'* YANG LAMA

LAMPIRAN 13
TUTORIAL PENGGUNAAN *'WATER BALANCE MODEL'* YANG LAMA
(Courtesy of www.waterbalance.ca)

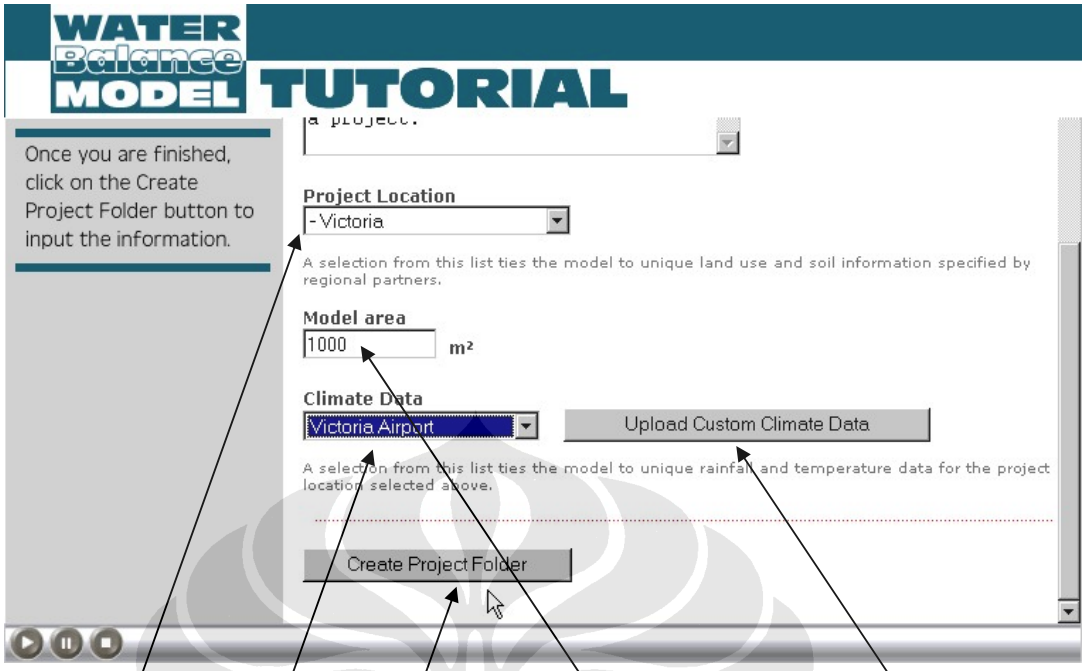
LAMPIRAN 13.1

CREATE A NEW PROJECT



Nama Proyek

Deskripsi Proyek



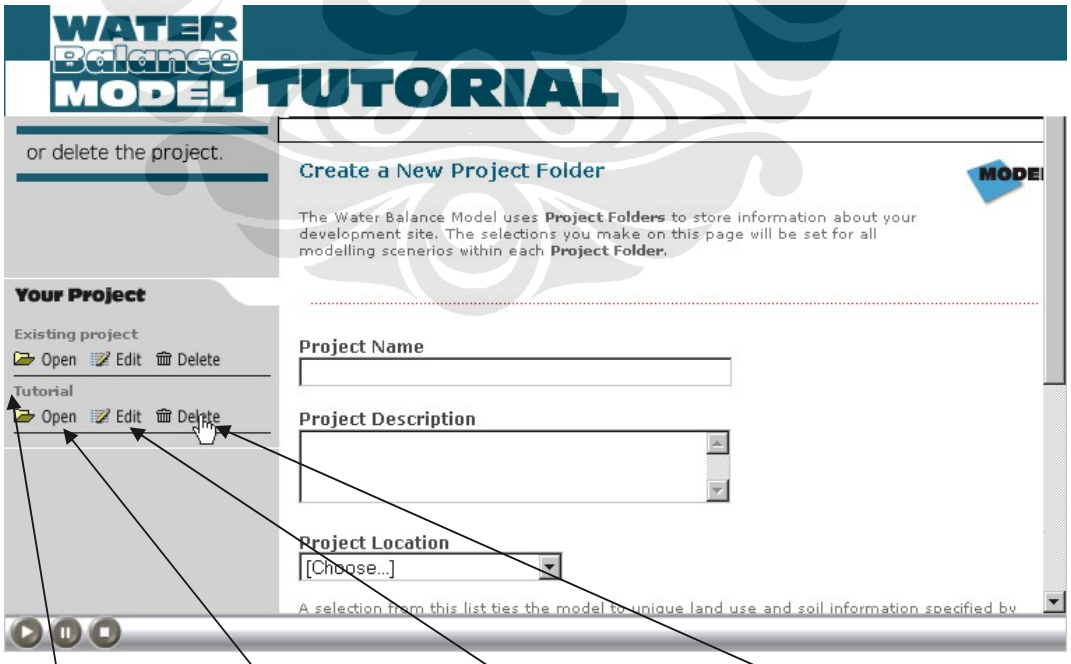
Lokasi Proyek

Data Iklim

Luas Lokasi Proyek (m^2)

Buat Map Proyek

Tambahkan Data Iklim



Tempat Proyek Tersimpan

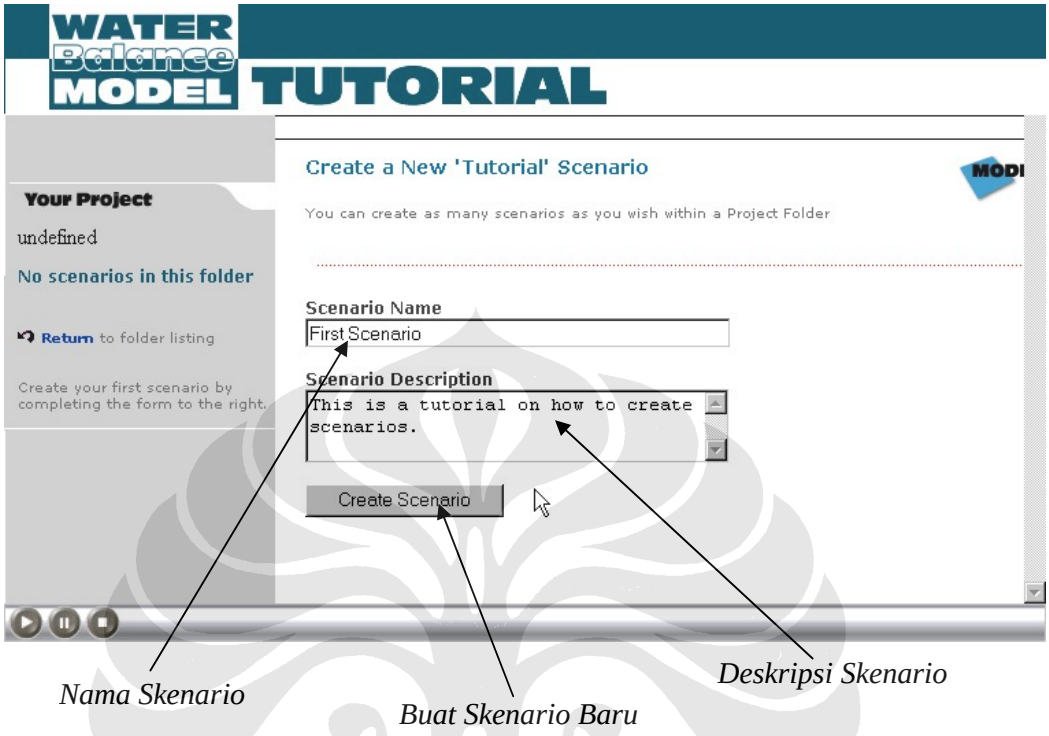
Membuka Proyek yang Tersimpan

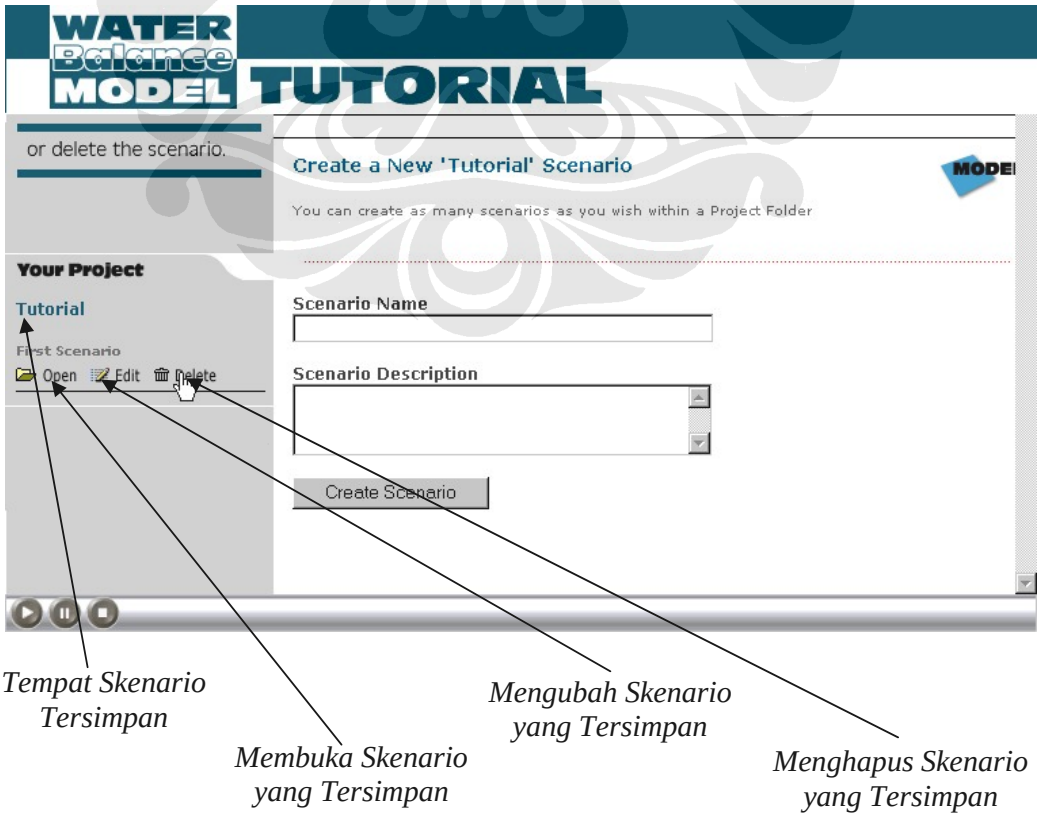
Mengubah Proyek yang Tersimpan

Menghapus Proyek yang Tersimpan

LAMPIRAN 13.2

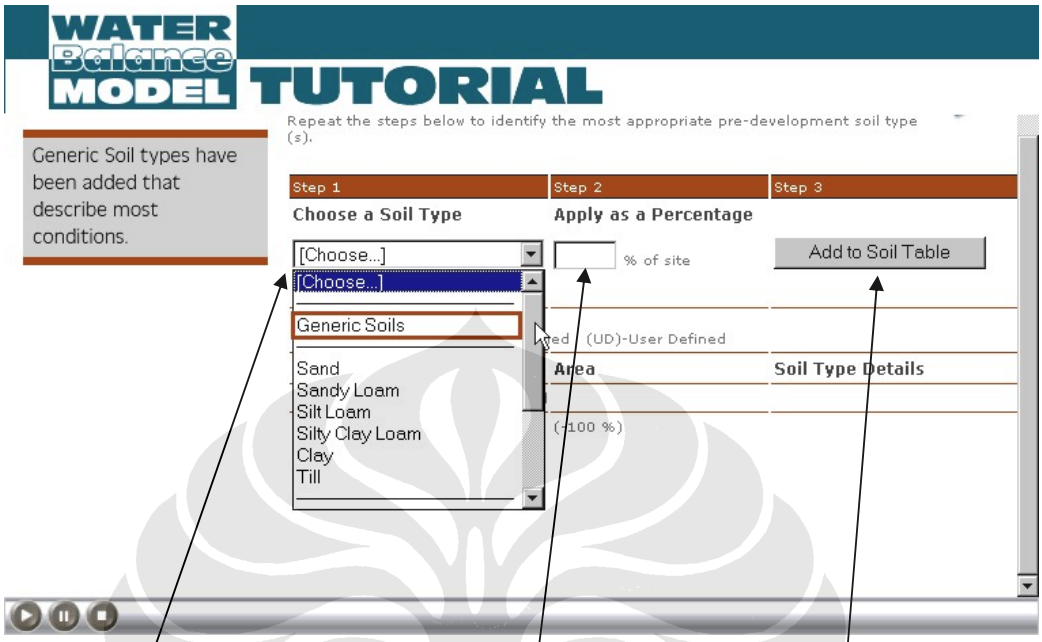
CREATE A NEW SCENARIO





LAMPIRAN 13.3

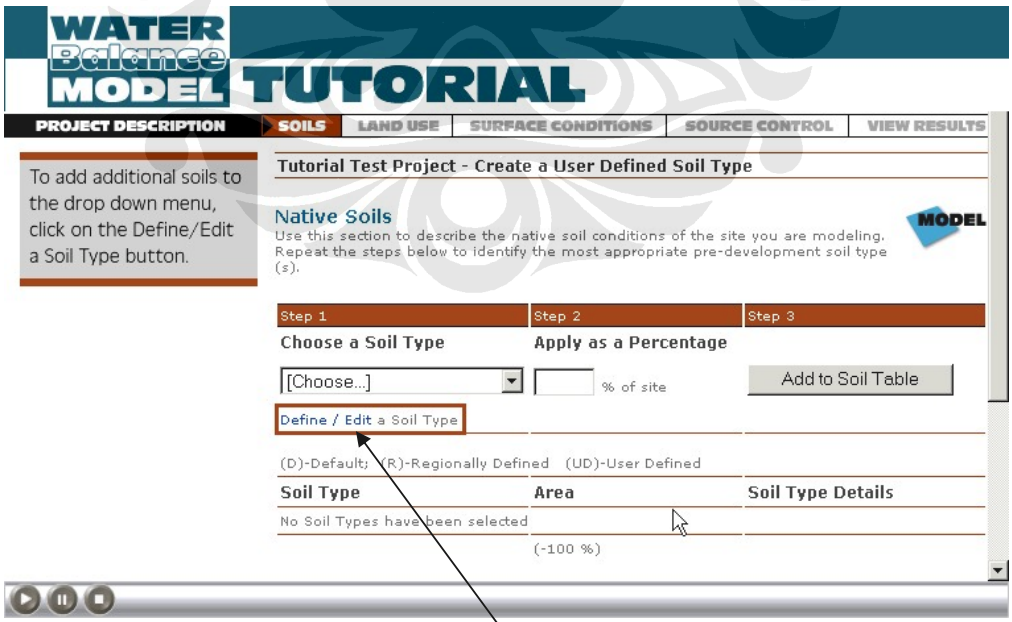
DESCRIBE NATIVE SOILS



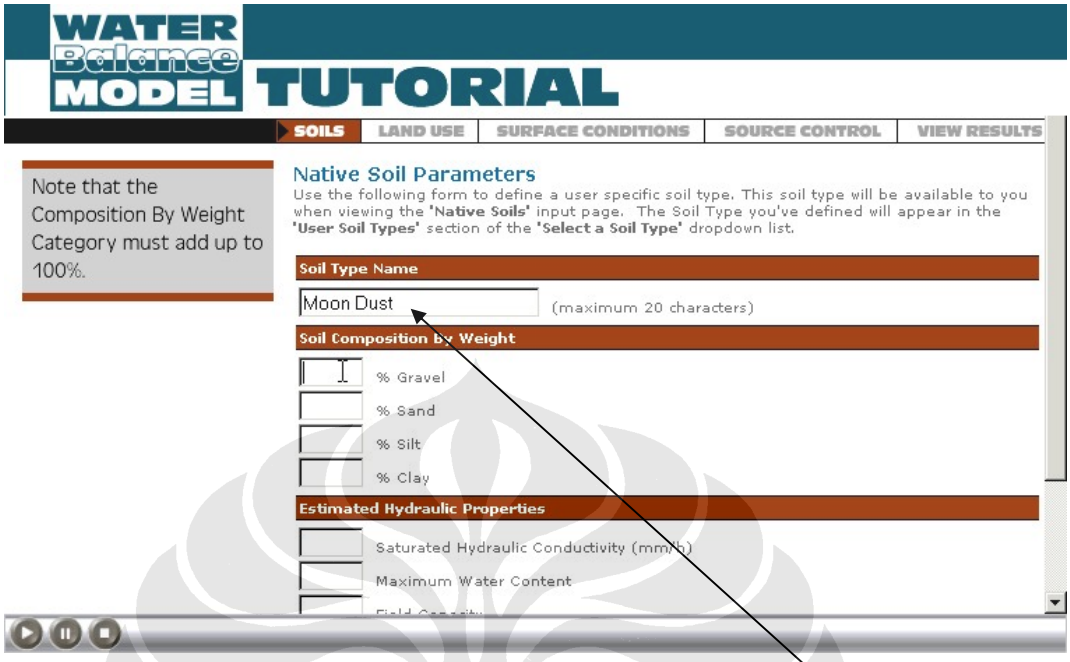
Tahap 1: Memilih Tipe/Jenis Tanah

Tahap 2: Masukkan Tipe/Jenis Tanah Sebagai Persentase

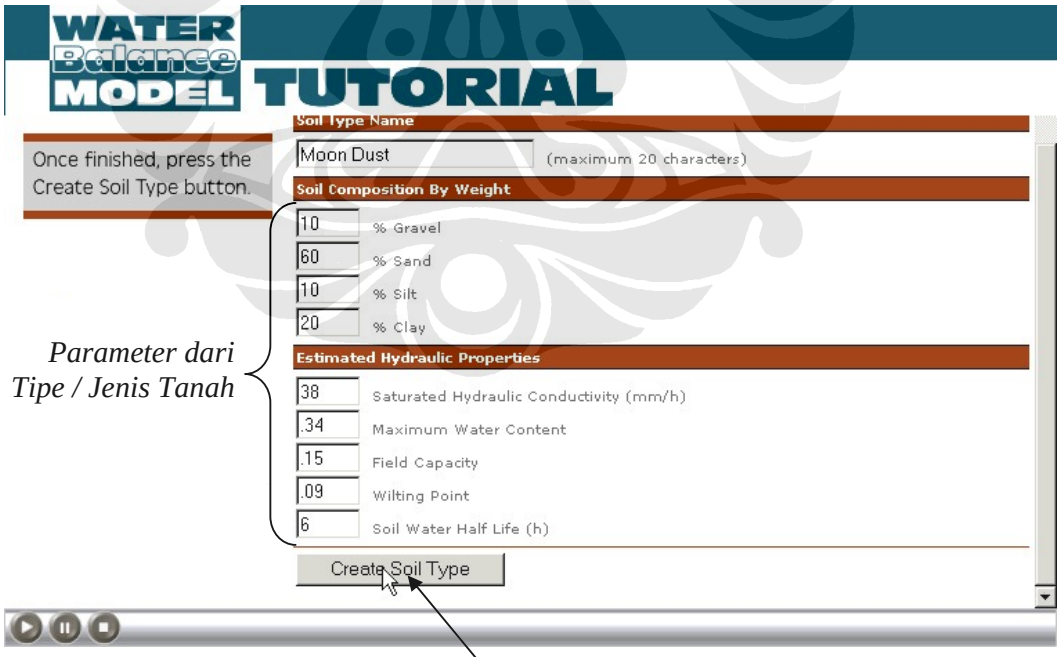
Tahap 3: Tambahkan pada Tabel Tanah



Untuk Menambah / Mengubah Suatu Tipe / Jenis Tanah Baru

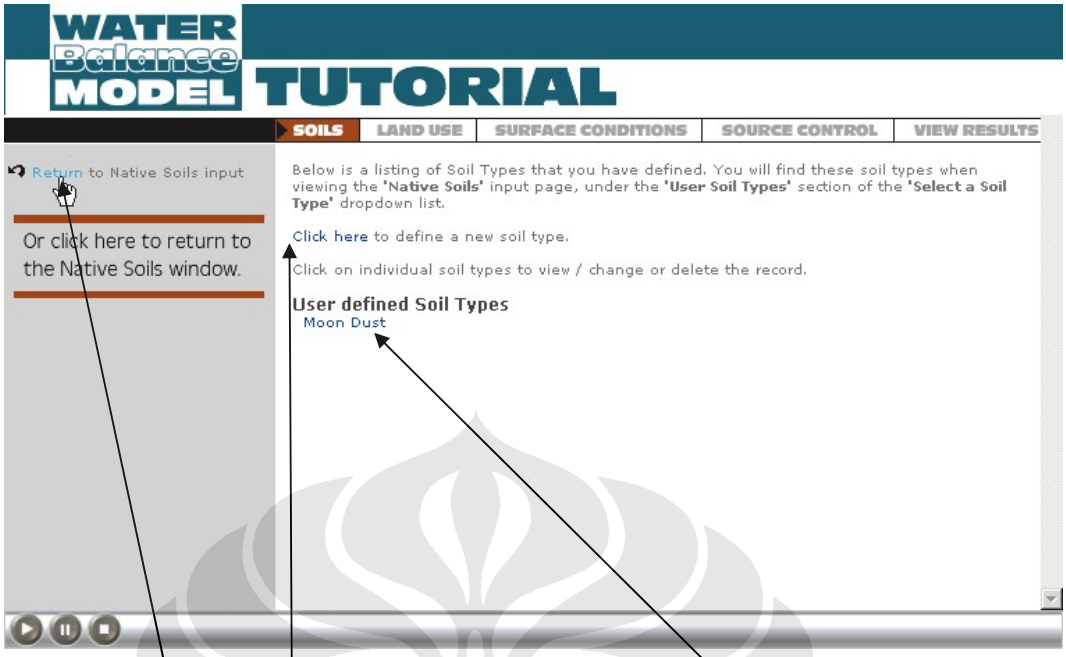


Nama Tipe/Jenis Tanah Baru



Parameter dari Tipe / Jenis Tanah

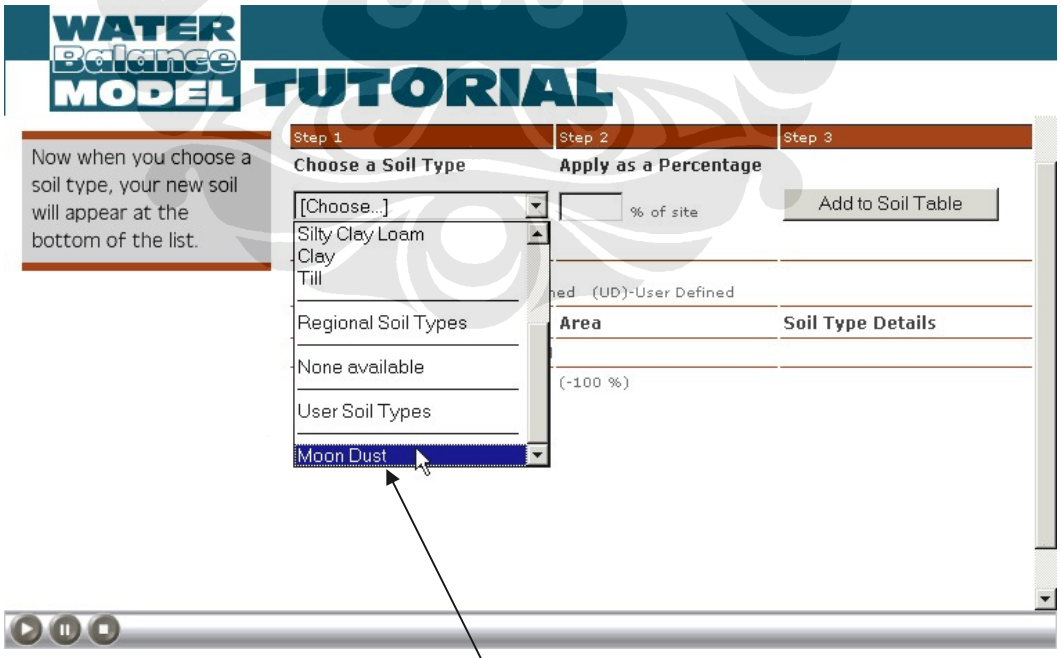
Buat Tipe / Jenis Tanah Baru



Kembali kepada halaman awal untuk memilih tipe / jenis tanah

Membuat tipe / jenis tanah baru

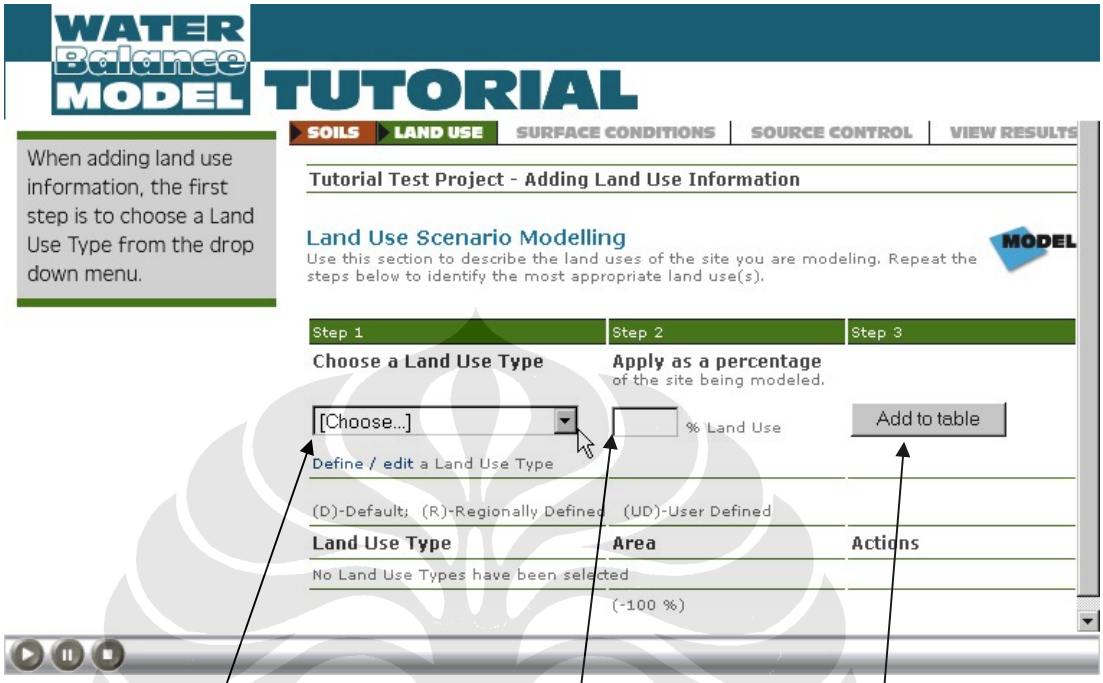
Tipe / Jenis tanah baru yang sudah dibuat



Tipe / jenis tanah yang sudah dibuat tercantum pada bagian 'User Soil Types'

LAMPIRAN 13.4

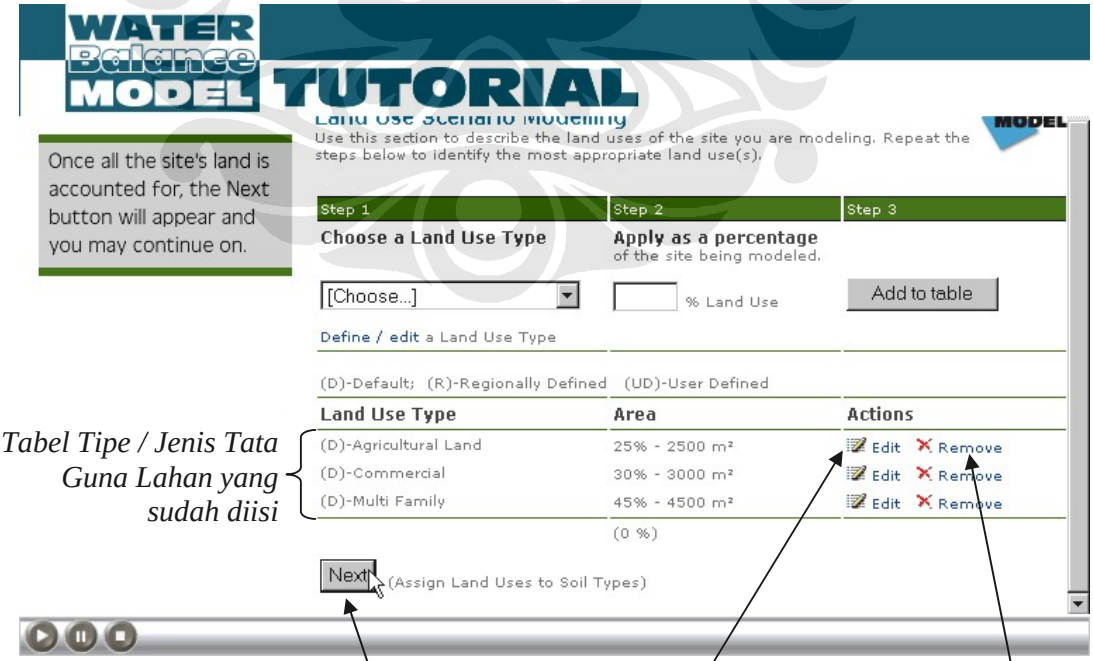
ADD LAND USE INFORMATION



Tahap 1: Memilih Tipe/Jenis Tata Guna Lahan

Tahap 2: Masukkan Tipe/Jenis Tata Guna Lahan Sebagai Persentase

Tahap 3: Tambahkan pada Tabel Tata Guna Lahan



Tabel Tipe / Jenis Tata Guna Lahan yang sudah diisi

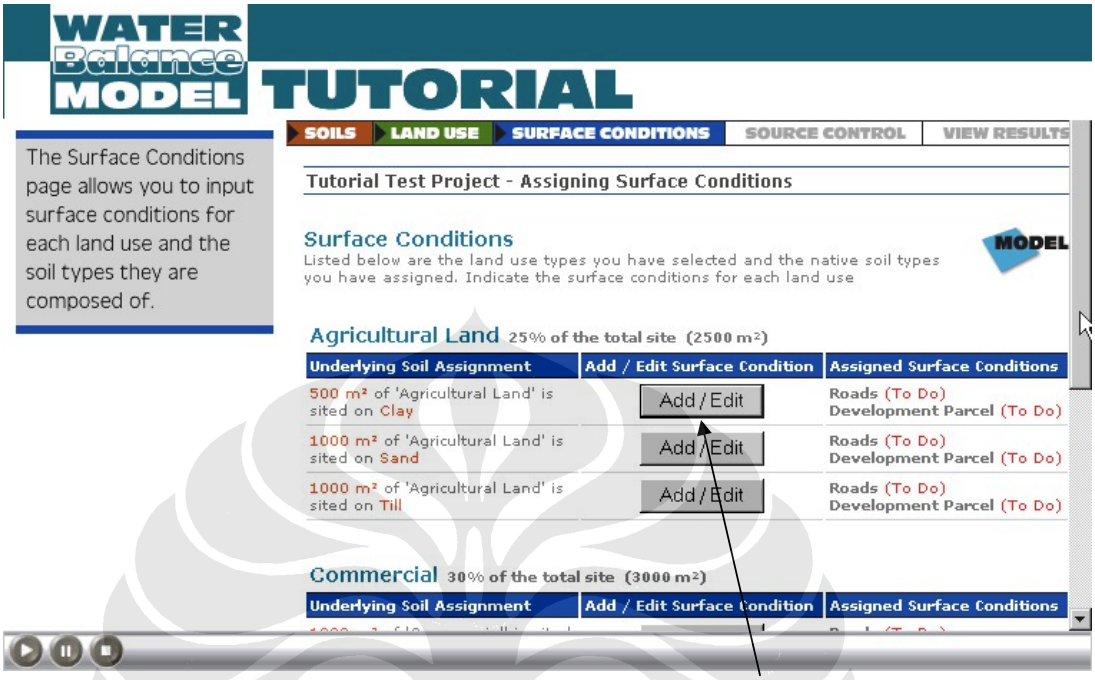
Melanjut kepada bagian berikutnya

Mengubah Skenario yang Tersimpan

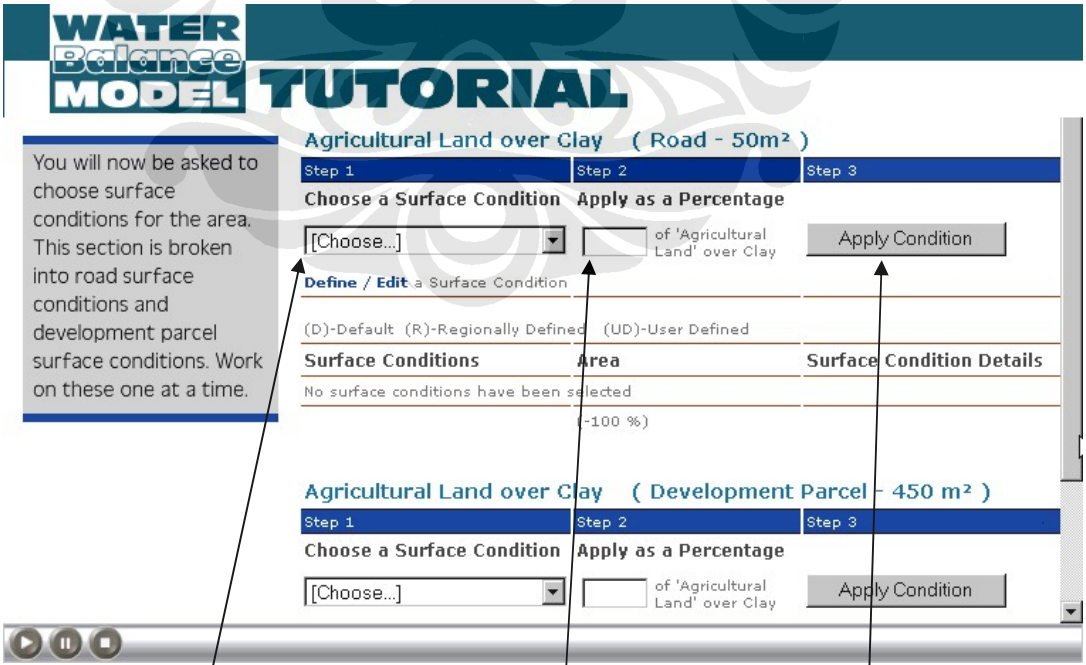
Menghapus Skenario yang Tersimpan

LAMPIRAN 13.5

DESCRIBE SURFACE TYPES



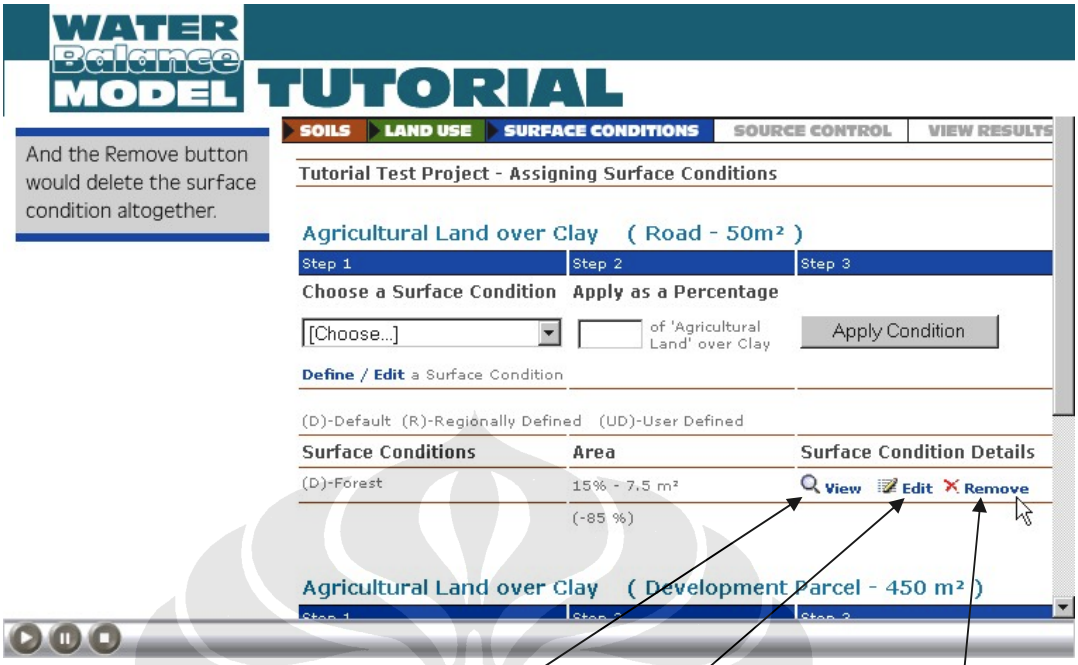
Tambahkan / Ubah kondisi permukaan pada masing-masing tata guna lahan dan tipe / jenis tanah yang terdapat pada lahan tersebut



Tahap 1: Memilih Kondisi Permukaan

Tahap 2: Masukkan Kondisi Permukaan Sebagai Persentase

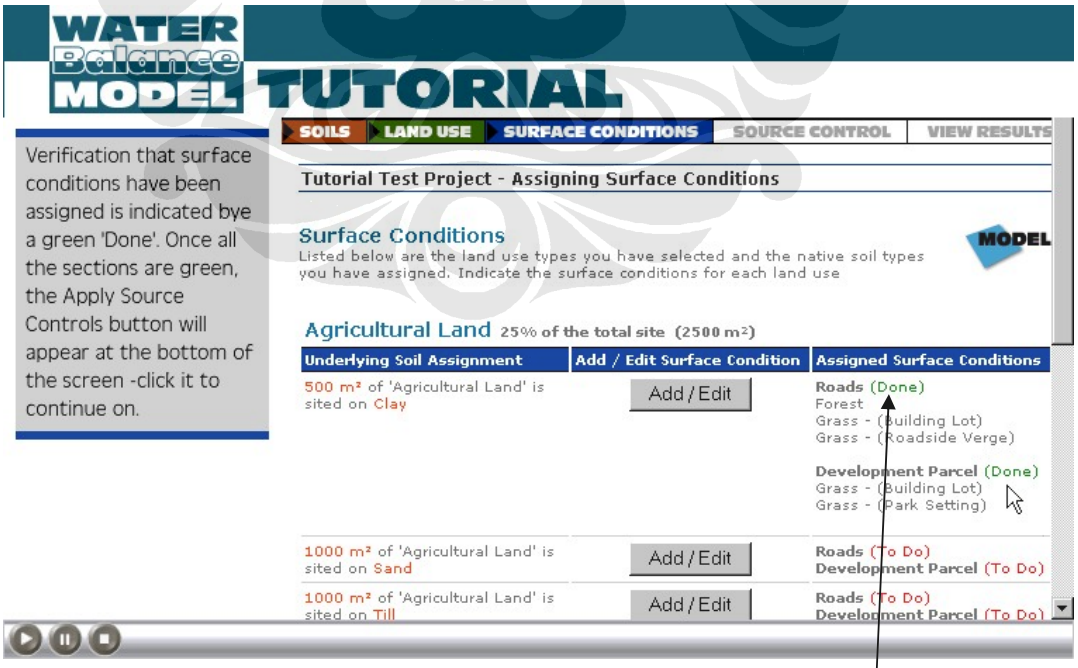
Tahap 3: Aplikasikan Kondisi Tersebut



Melihat detail parameter tipe / jenis tanah pada permukaan lahan tersebut

Mengubah kondisi permukaan yang tersimpan

Menghapus kondisi permukaan yang tersimpan



Verifikasi bahwa kondisi permukaan sudah dimasukkan