Design Details for Constructed Wetlands

based on the example of the

presented by

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for the

Ecological Sanitation Online Course

UNESCO-IHE
Institute for Water Education

Background:

Financing Agency: ADA (Austrian Development Agency)

Beneficiary: TBC Hospital Jasenovo, Municipality of Caska, Republic of Macedonia

Engineer: Posch&Partners Consulting Engineers (Project Management, Design, Tendering and Construction Supervision)

Contractor: DGT “ZIKOL”, Construction Company, Strumica, Republic of Macedonia

Follow-up project after improvement measures on water supply system were realised (2003-2005)

Project period: February – October 2006

Existing Waste Water (WW) Situation

Collection of Hospital WW by an old brick sewer in a not maintained and non-operating septic tank

Uncontrolled discharge of tank effluents

Uncontrolled discharge of laundry effluents

Why opting for a Constructed Wetland?

Jasenovo Hospital is situated in remote area (on-site treatment necessary) with sufficient land availability

Territory was found to be suitable for gravity driven operation (sufficient height difference) – no power supply necessary

Waste water treatment in proximity to Hospital: CW offer nice appearance in recreational surrounding

CW are low on O&M measures – operation by trained hospital staff possible

Design Parameters

Design based on Austrian standard ÖNORM B2505 (standard for use, design, construction and operation of CW)

Key points:

- Standard valid for CW for communal sewage < 500 PE
- Standard covers horizontal sub-surface flow (HSSF) and vertical sub-surface flow (VSSF) CW
- Avoidance of toxic substances and stormwater → separate sewer system preferred
- Nominal hydraulic load: 150 l/(PE*d)
- Nominal pollutant load: 60 g BOD_5/(PE*d)
- Mechanical pre-treatment by screen and sedimentation tanks essential → avoidance of clogging of CW filter bed

Pollution Load Calculation

POLLUTION LOAD JASENOVO HOSPITAL

Consumer Groups	Unit	Max. future Units	Specific Pollution Load [g BOD5/d]	Total future Pollution Load [g BOD5/d]
Stationary Patients	Bed	120	60	7200
Ambulant Patients	Patient	12	15	180
Workers and Management (from 07:00am to 14:00pm)	Capita	48	20	960
Medical Personnel (permanent)	Capita	12	60	720
Kitchen	meals	264	16	4277
Laundry	kg	60	12	720
Domestic consumption (5 houses) (In future houses will be used for private patients)	Capita	15	60	900
Sub Total				**14957 g BOD5/d**

Design population equivalents (PE) (=total BOD5 load / 60g BOD5/PE) **249**

Main Plant Components

Pre-treatment:

- Screen with free spacing = 20 mm (manually cleaned)
- 3-chamber septic tank V1 : V2 : V3 = 2 : 1 : 1

V_{tot} = 0.25 [m^3/PE] * 50 [PE] + 0.15 [m^3/PE] * (249 – 50) [PE]
= 42 m^3

i.e. 0.25 m^3 for first 50 PE and
0.15 m^3 for every PE above 50

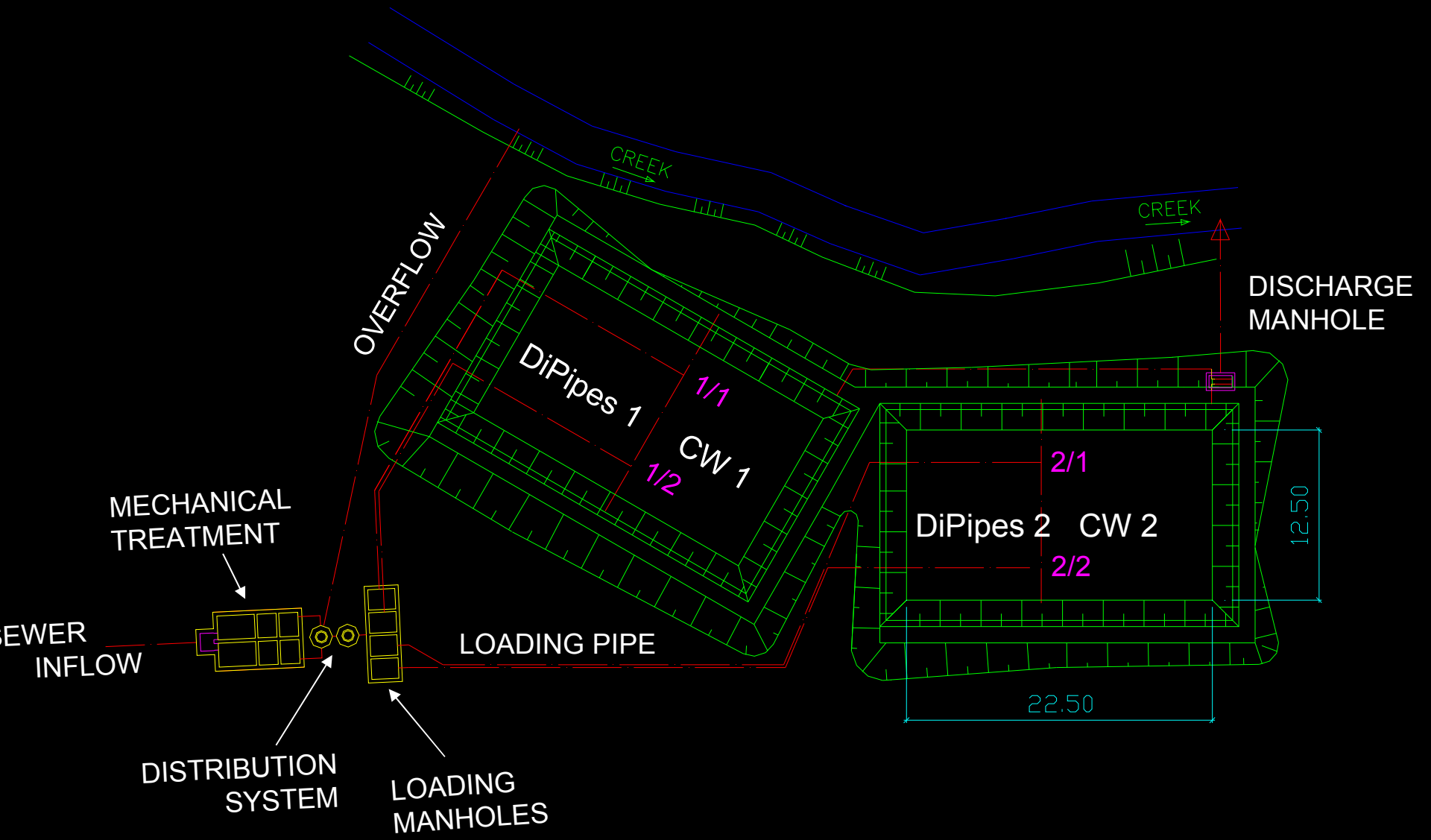
Constructed Wetland:

Reduction of BOD_5/(PE*d) to 40 after mech. pre-treatment allowed

- Type: VSSF CW → 4 m^2/PE
- Area required = 249 [PE] * (40/60) [g BOD_5/d] * 4 [m^2/PE]
= 665 m^2
= 2 beds with 333 m^2

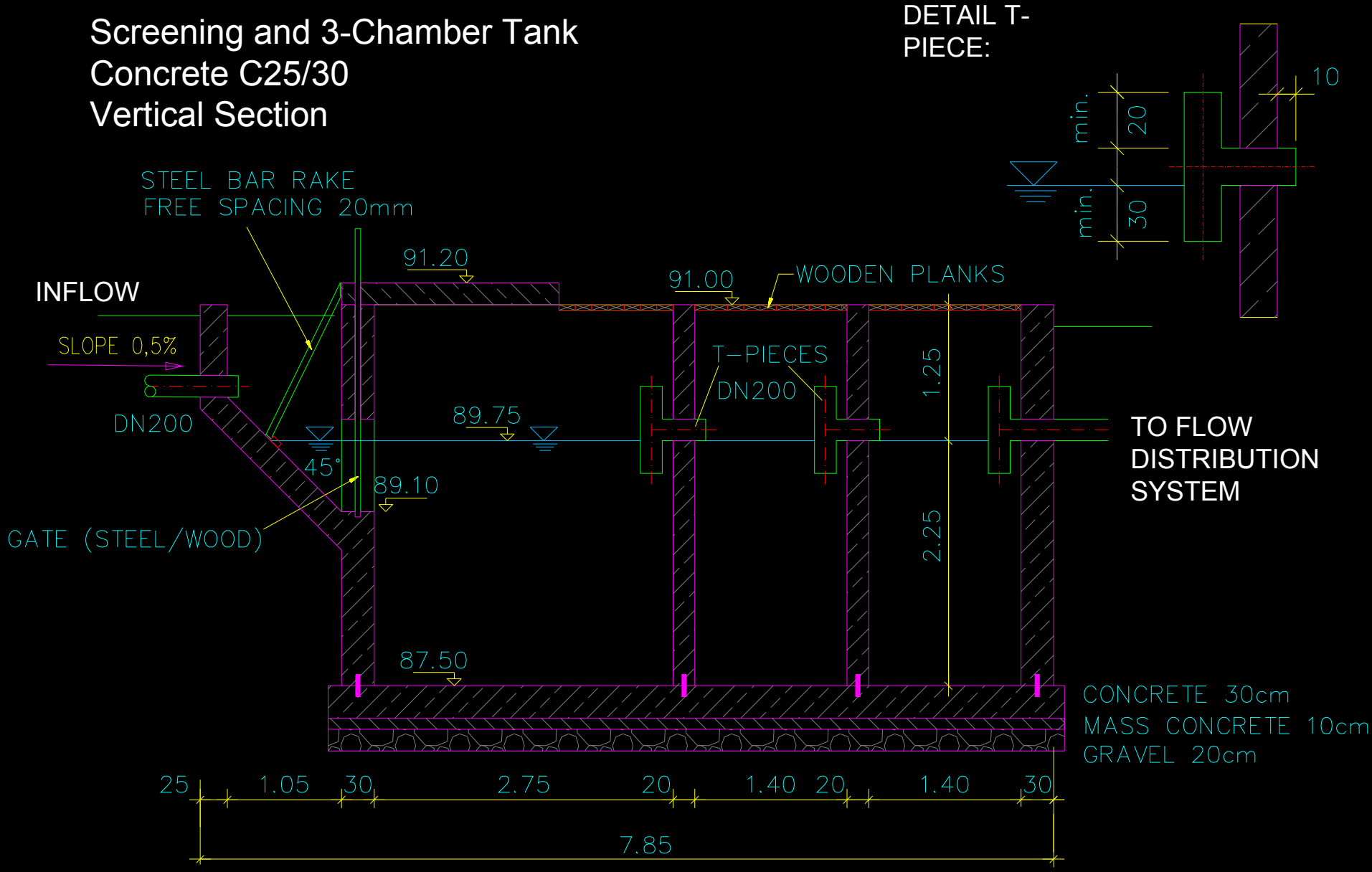
Max. recommended single bed size
400 m^2

Plant Overview



Details Pre-Treatment

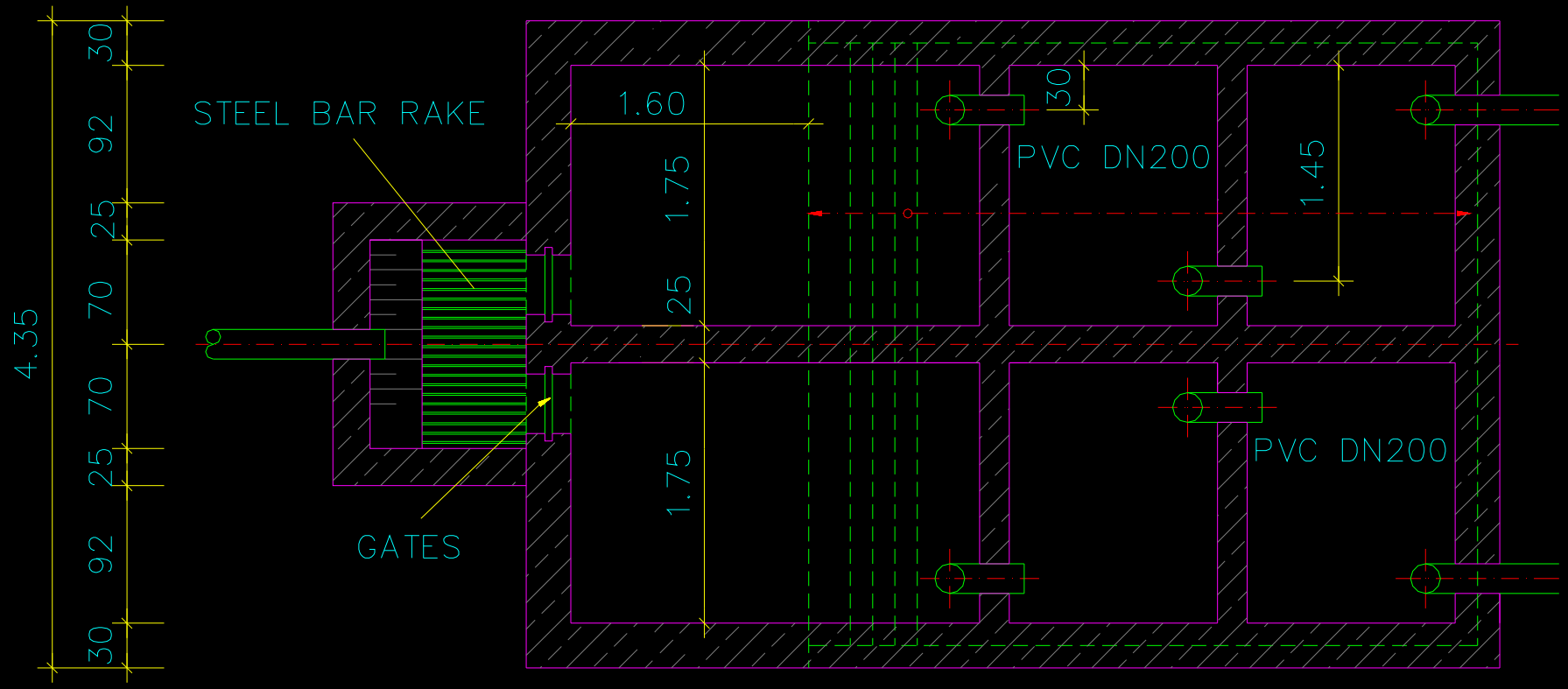
Screening and 3-Chamber Tank
Concrete C25/30
Vertical Section



Details Pre-Treatment

Screening and 3-Chamber Tank
Concrete C25/30
Ground View

NOTE:
Crosswise position of T-pieces
Parallel chambers for cleaning – gates for closing

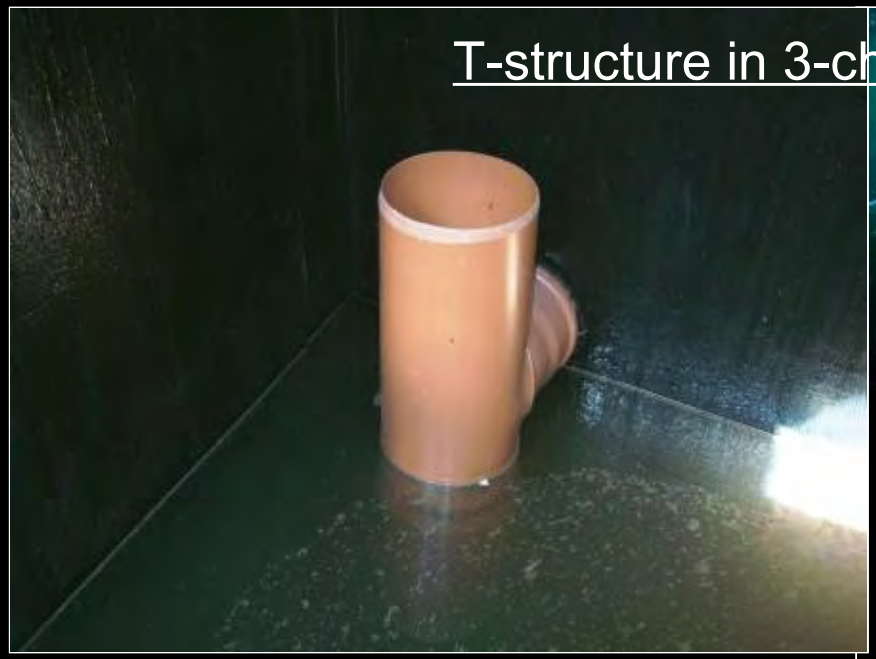


Construction of Pre-Treatment Unit

Concreting base slab 3-chamber tank

Reinforcement & shuttering 3-chamber tank

Realised Details of Pre-Treatment Unit



T-structure in 3-chamber tank

Inflow and steel rake

Inflow gate

Flow distribution & Hydraulic Valves

Loading of CW beds with WW shall be intermittently in order to facilitate oxygen diffusion

Loading interval between 3 and 6 hours; max. duration / loading: 15 min.

Loading by pumps or by hydraulic systems (gravimetrically driven)

Hydraulic systems require 1,50m height difference to the CW beds as a minimum

Hydraulic systems may require further division of CW beds → flow distribution necessary

Chosen for Jasenovo:

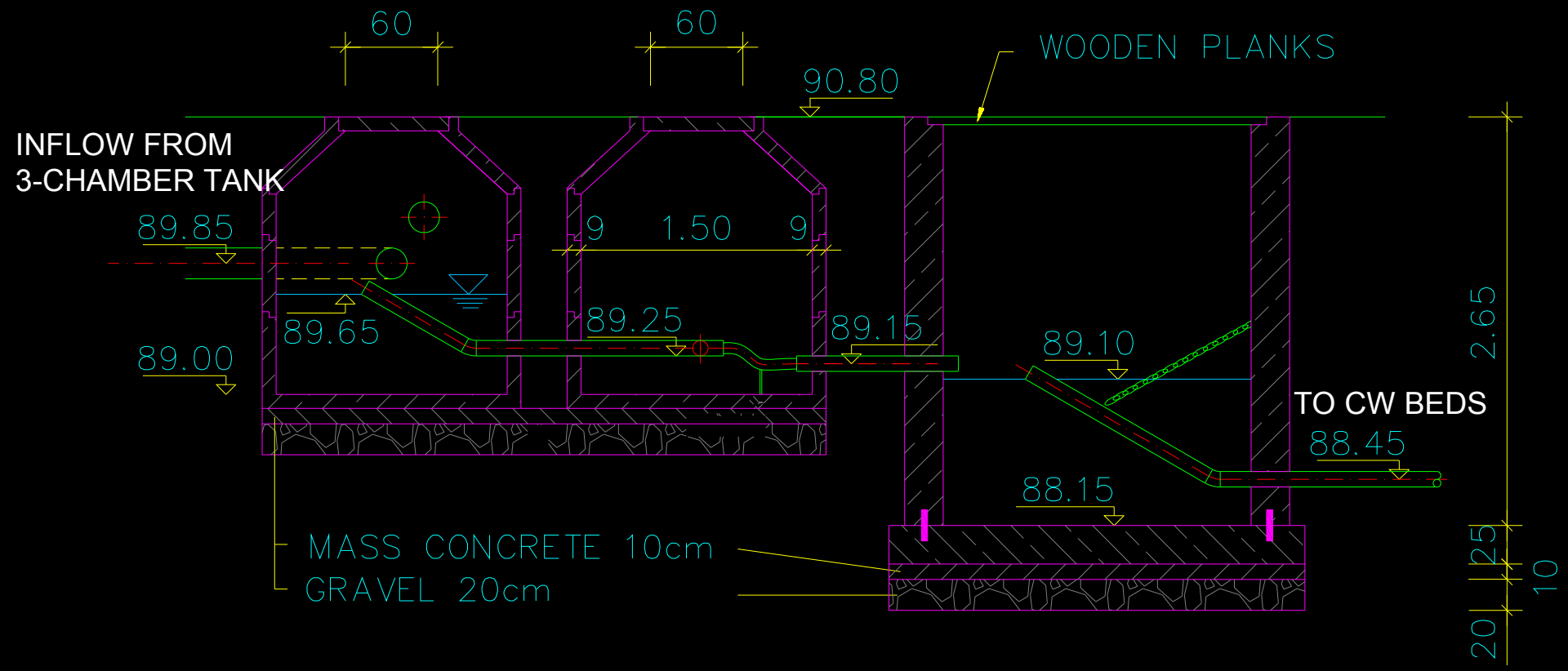
- Use of hydraulic valves
- Two separate distrib.systems per CW bed → 4 separate systems in total
- Flow distribution by another hydraulic valve and pipe system

Details Flow Distribution System

Vertical Section

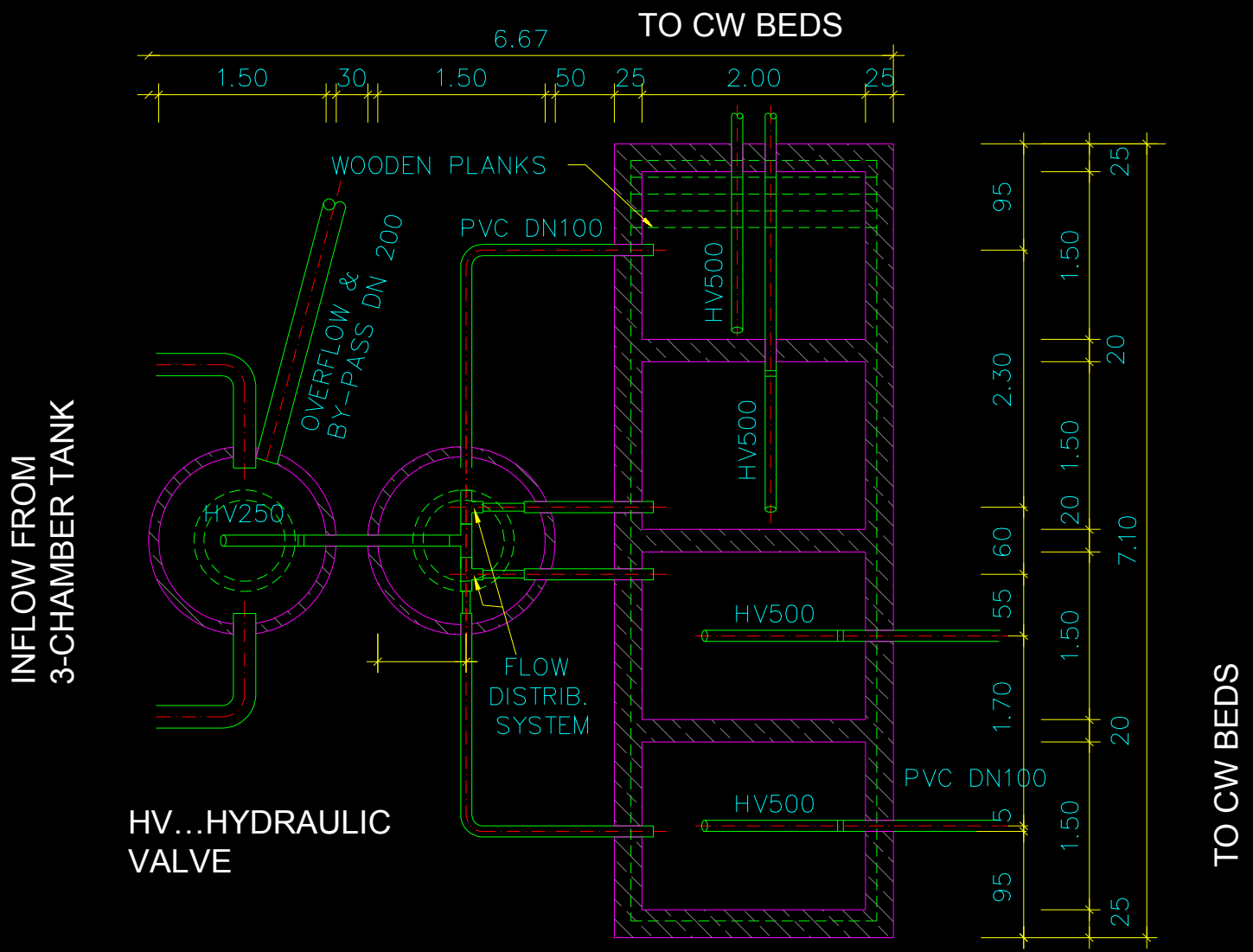
DISTRIBUTION MANHOLES
PREFABRICATED CONCRETE
WITH HYDRAULIC VALVE 250 l/min
AND FLOW DISTRIBUTION UNIT

LOADING MANHOLES
CONCRETE C25 / 30
WITH HYDRAULIC VALVES 500 l/min



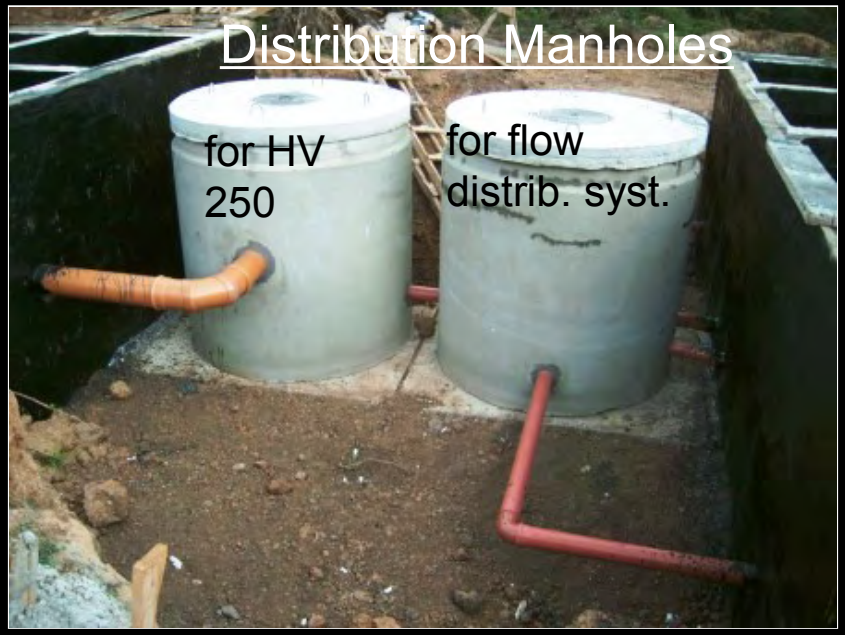
Details Flow Distribution System

Ground View



Flow Distribution in Practice

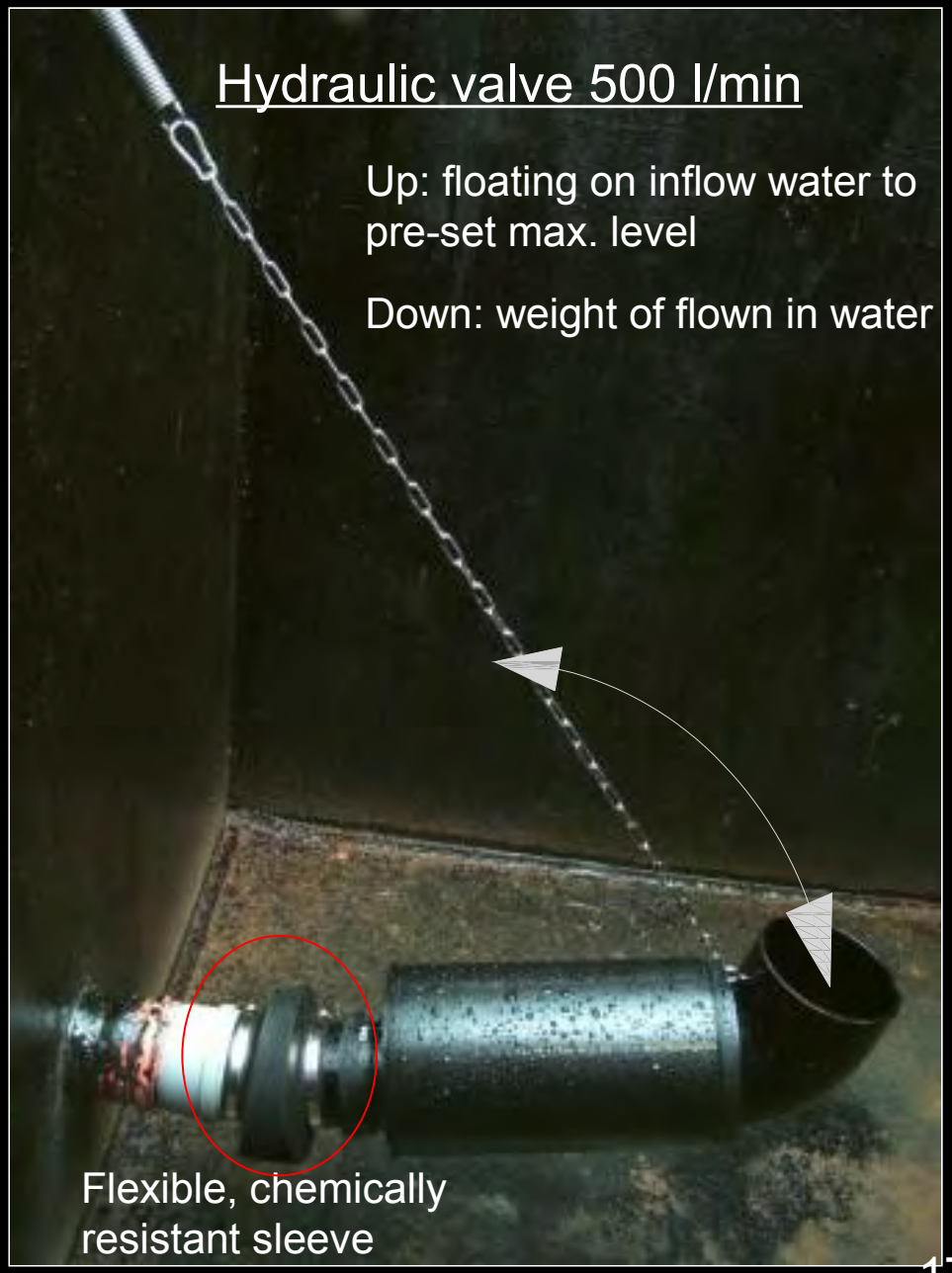
Distribution Manholes



Pipe Inlet Detail

Flow distribution system

Construction of Loading Manholes

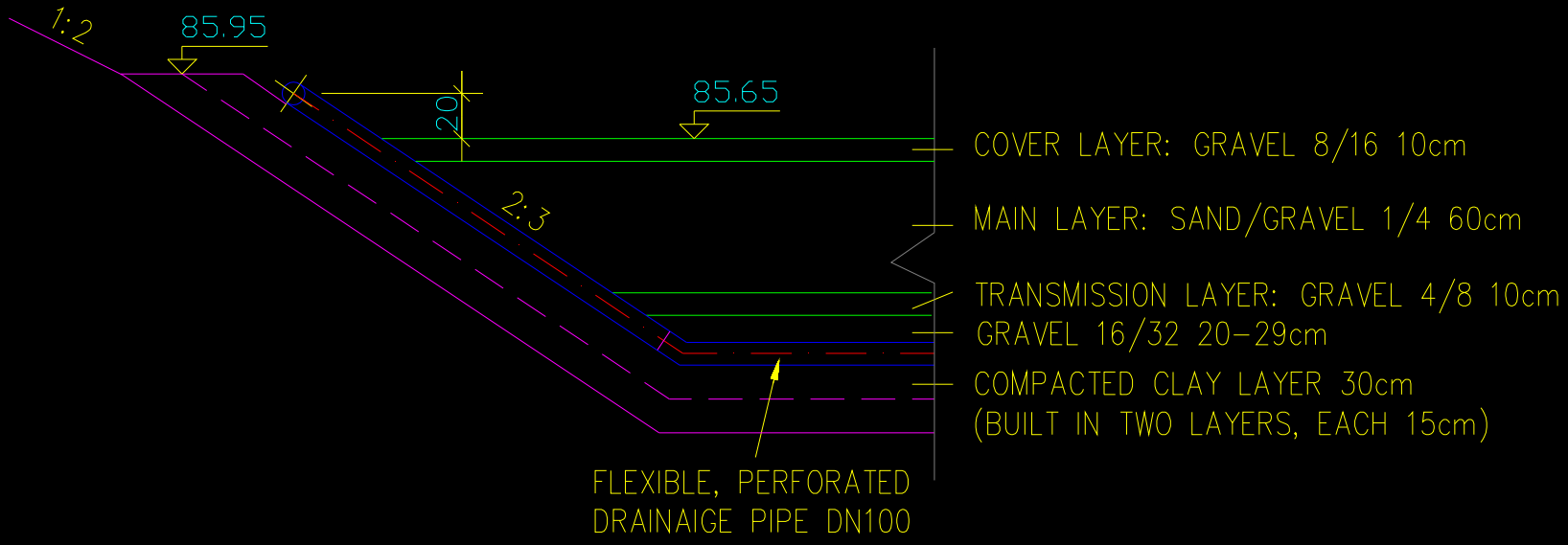


CW Beds (VSSF Beds)

Main filter layer shall have a permeability coefficient of
$k = 10^{-4} - 10^{-3}$ m/s and be of high mechanical stability (sand, gravel)
Avoid unnecessary compaction of layers, also during construction → no vehicles on gravel or sand!

Beds need to have impermeable base and side walls:
- either clay layer ($k \leq 10^{-7}$m/s), 30 cm thick, compacted in 2 layers to 95% Proctor density (ρ_{Pr})
- or adequate sealing foil made of plastic

Detail Cross Section CW Beds



Excavation and Sealing of CW Beds

Layers and Drainage of CW Beds

Cover layer (gravel 8/16) 10cm

Main layer (sand/gr 1/4) 60cm

Transm. layer (gravel 4/8) 10cm

Clay sealing layer and perforated drainage pipes (solid, non-perforated pipes put over them at embankments, see also slide 24)

WW distribution on CW beds

WW needs to be equally distributed on CW beds → minimum one discharge point per 2m^2 of bed surface

Pressure pipes with singular discharge points or perforated (with boreholes) distribution pipes (either laid on bed surface or elevated on suitable blocks)

Minimum pipe diameter DN 40, boreholes 8mm

Pipes shall be UV resistant and have a small specific coefficient of linear expansion [mm/(m x °C)]

Stainless steel bolts can be used for fixing spigot socket joints of distribution pipes

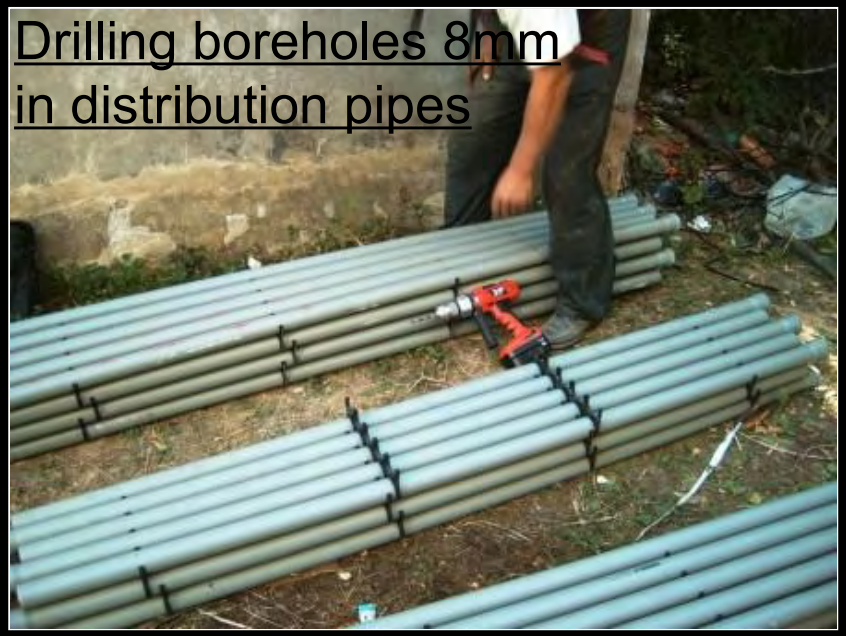
Distribution pipes shall foresee flushing access and drain-off automatically (avoid freezing)

Distance between two parallel pipes shall be limited to 1m

High temperature stabilized Polypropylene-Copolymer (HT-PPCO) pipes DN 50, elevated on concrete blocks, were chosen

WW Distribution on CW Beds in Practice

Drilling boreholes 8mm in distribution pipes



Main feeding pipe to CW beds

Pipe clamps on concrete blocks

Bolts for spigot socket joints

WW Distribution on CW Beds in Practice

Alignment of concrete blocks

Taper piece for flushing

Water outflow of distribution pipe

In case of higher flow rates a baffle shall be used

Laid distribution system

Further Plant Components and Details

Drainage:
- CW base shall be sloped (0.5 – 1 %)
- For better drainage, drainage pipes DN ≥ 80 can be laid in max. distance of 3m; for aeration and flushing pipes shall be extended above bed surface (see slide 20)

Wetland Plants:
- Plants shall have deep roots and reeds have shown best suitability
- Planting is best during growing season (spring to summer) but possible year-round
- Locally available seedlings (not grown up plants) shall be used
- Approximately 5 plants / m^2 shall be planted
- In Jasenovo 75% Phragmites Australis and 25% Typhia Latifolia were planted (however in autumn!)

Surface run-off:
- Avoid inflow of surface run-off of surrounding area (e.g by ditches, etc.); sediments (especially recently after construction) might contribute to clogging of the CW beds

Discharge Manhole:
Percolated, treated WW shall be collected in a discharge manhole for:
- Sampling and water quality control
- Weed control in CW beds by raising water levels in CW beds

Planting of Wetland Plants

Discharge System

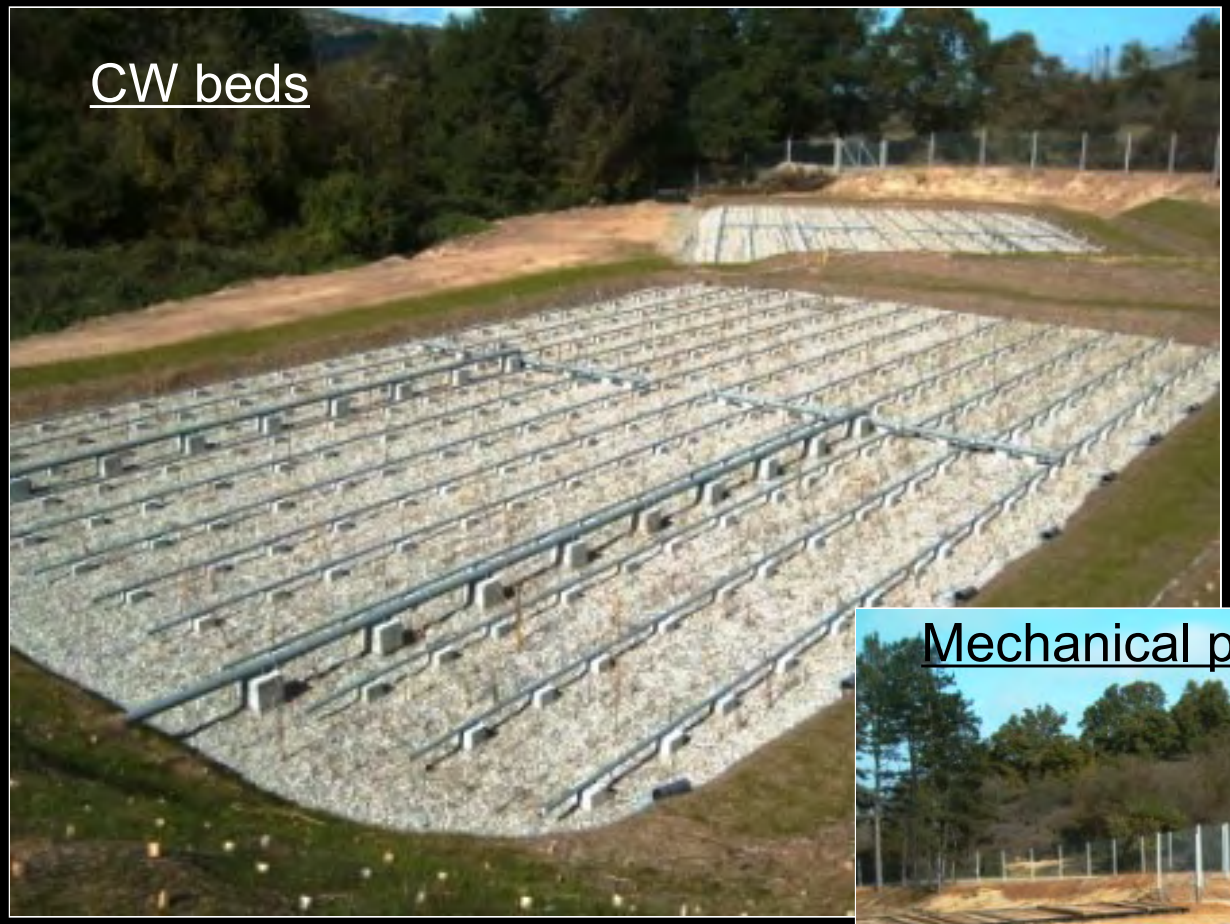
Discharge manhole

Discharge pipe into outfall drain

Water level regulation in CW beds by turning bends in discharge manhole up and down

NOTE: Lower water level only very slowly (some cm / d) in order to avoid compaction of filter layers

Final Overview and Costs



Total costs*:

Supply of Materials: 15,200 Euro
Construction Works: 76,700 Euro

(average salary of skilled worker in MK: approx. 300 Euro / months)

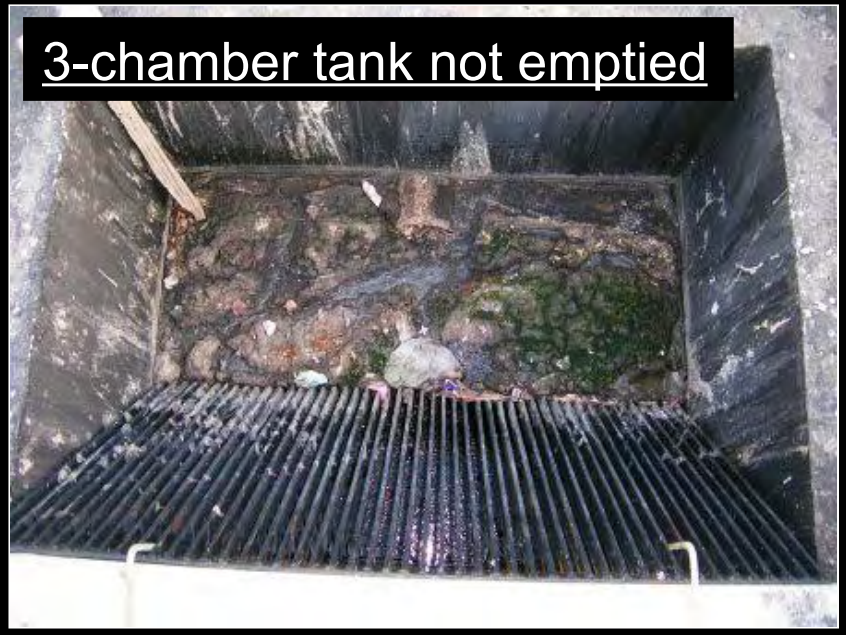
* incl 190m new sewer line

Problems encountered in June 2007

Overview plant growth

Plant density partially not satisfying → re-planting

3-chamber tank not emptied



Unsecured joints loosened

Thank you!

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