



A black and white scanning electron micrograph (SEM) showing a highly porous, honeycomb-like structure. The structure consists of numerous small, interconnected cells or chambers, creating a complex, mesh-like appearance. Two prominent, dark, irregularly shaped voids or cavities are visible within the structure, one towards the upper left and another towards the lower left. The overall texture is rough and granular.

Biochar In Stockholm

100 years



15 years



50 years



1980-2012



6 years
Toffelbacken



100 years



15 years



75 years



conventional construction
for sidewalks in
Stockholm
a completely sealed
surface where no water
can be infiltrated or gas
exchange can take place



More than 40
years on the
site



Compaction of soil and dense surface layers the main reason that trees do not grow in urban environments



- subgrade
- sorted stone material 0-8, 0-16, 0-32, 0-63mm
- grain sizes between zero and upper grain fraction are included



Simet 9-64

KORNGRUPPSKALA

Fint grus	6	— 2	m/m	
Grovsand	2	— 0,6		bedplon
Mellansand	0,6	— 0,2		huggatop
Grovmo	0,2	— 0,06		
Finmo	0,06	— 0,02		hjalgräs
Mjåla	0,02	— 0,002		Grov mask 45-75 Fin 20-40
Ler	<	0,002		Stenmjål 45 Fyller < 90

Gravt grus 6-20
Sten 20-200
Block > 200
Mindre 20-60
Sten 60-200

Ler Mjåla Finmo Grovmo Mellansand Grovsand Fint grus

soil profile
with several
layers of
different
materials







Compaction of soil and dense surface layer
biggest reason that trees do not grow





2000-5000 år





Stenkap

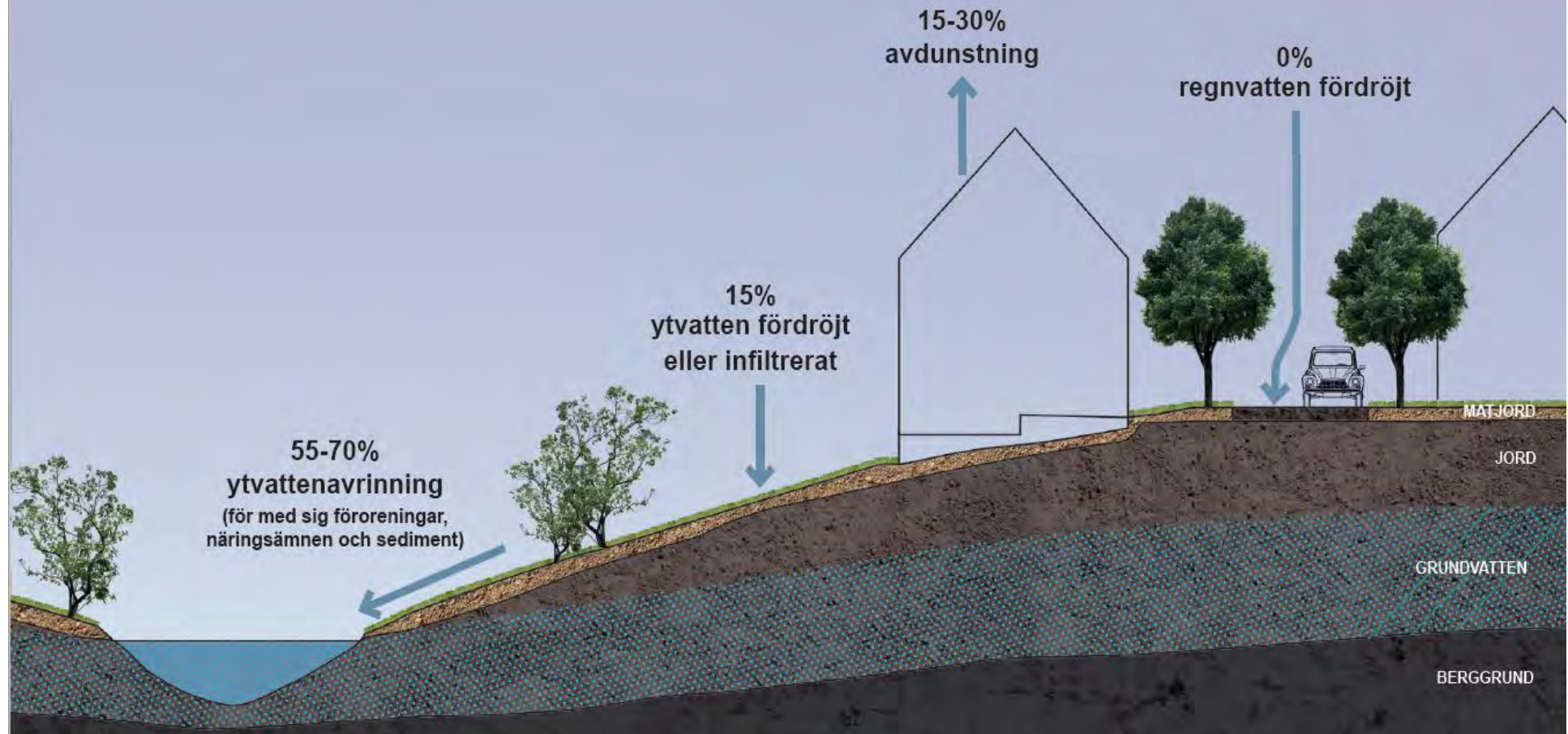


Bilhammare

Toffelbacken
Compacted soil



Störd markprofil – infiltration som fungerar dåligt





Small
stream



Bällstaån

Lokalt åtgärdsprogram

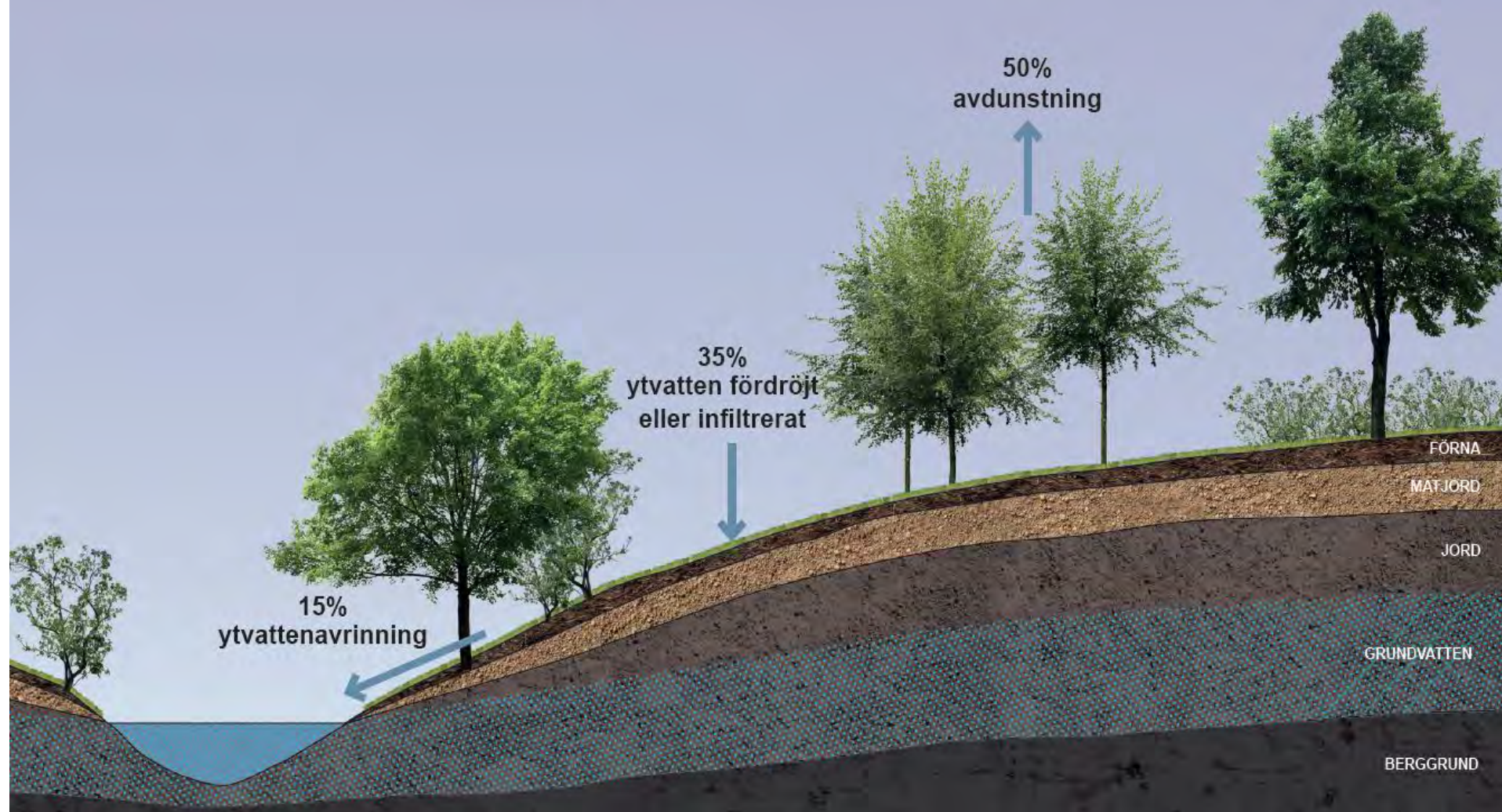
På väg mot god
vattenstatus
och anpassad för
framtidens klimat

Åtgärdsbehov i
Stockholms stad
Augusti 2017

action
program

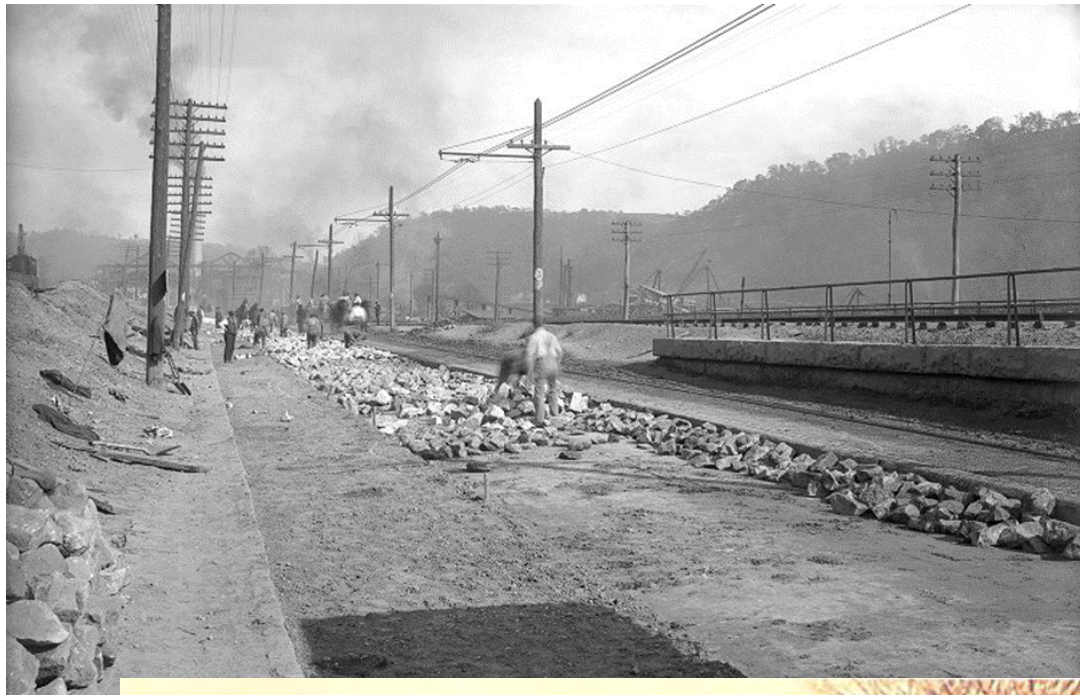


Naturlig markprofil – fungerande infiltration



Macadam is single-sized
crushed stone





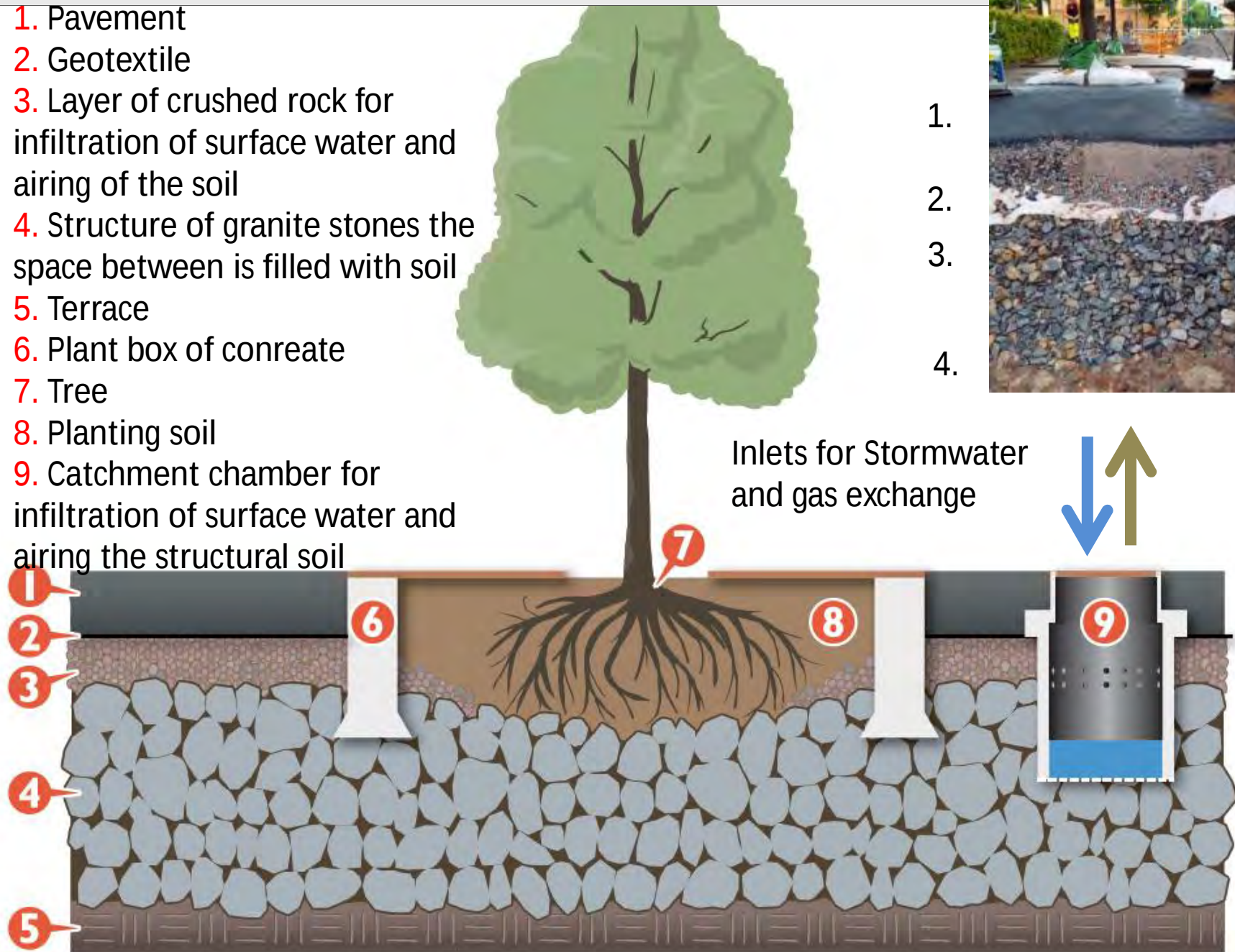
Using a loadbearing rock based growing substrate as a benefit for both for trees and stormwater management



Porosity around 40%

Structural soil How to create good growing conditions and taking care of the rain

1. Pavement
2. Geotextile
3. Layer of crushed rock for infiltration of surface water and airing of the soil
4. Structure of granite stones the space between is filled with soil
5. Terrace
6. Plant box of concrete
7. Tree
8. Planting soil
9. Catchment chamber for infiltration of surface water and airing the structural soil



The contents of the terasse affect the capacity of infiltration





Granit 90-150mm
Each layer 300 mm compacted for stability

Recycled concrete used as a part of the structural
soil instead of granite



Flushing the soil into the structure



Ventilation chamber and inlet of surface water



Slow release fertilizer



Layer for infiltration of rain water and aeration of the soil on top off the structural soil



Important with geotextile connection
against curbs inlets concrete boxes etc.so
that no fine material could run into the airy
base course



- We take water from roofs and pavements through inlets to the ventilated bearing layer and the structural soil.



If the percolation layer is full, the storm water flows into the old street inlet.



- Roof and pavement surface 4600kvm Rainfall 600mm year (2 fot)
Approximately 2.3 million liters of water year Saved cost for the treatment of stormwater = 2300 euro /year
Reduced load on the Baltic Sea / and lakes at torrential rains





structural soil after 4 year

soil after 6 year





we find mykorrhitza in our structural soils which only thrives in good conditions (planting pits acting as a biological filter)

September 2016

2007 first growing
season



Odengatan first growing season



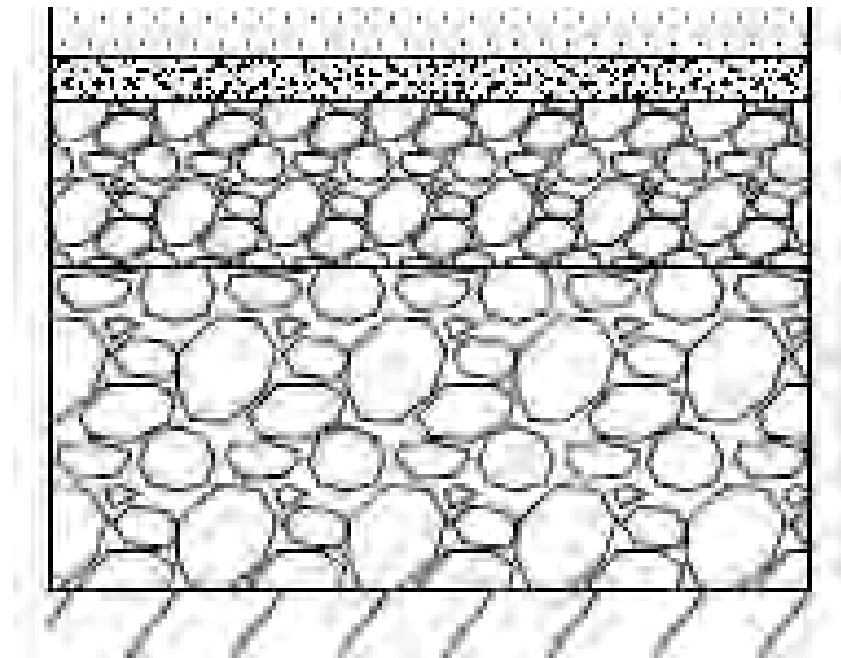
left 2002 right 2013 Kungsbroplan tree before and after structural soil



Recycled Concrete



Grusyta med trädplantering



70 mm Grusyta 50% 0-8 50% pimpsten 2-8
50 mm avjämningslager, 8-16 (4-16)

200 mm Luftigtbärlager 32-63

680 mm Skelettjord 90-150 jord typ D

Approximately 2 000 planting beds have been rebuilt with structural soil in the central parts of Stockholm



Stockholm Biochar Project



Stockholms
stad



Bloomberg
Philanthropies

Substitutes finite materials

Improves soil

Sequesters carbon

Retains water and nutrients

Biochar

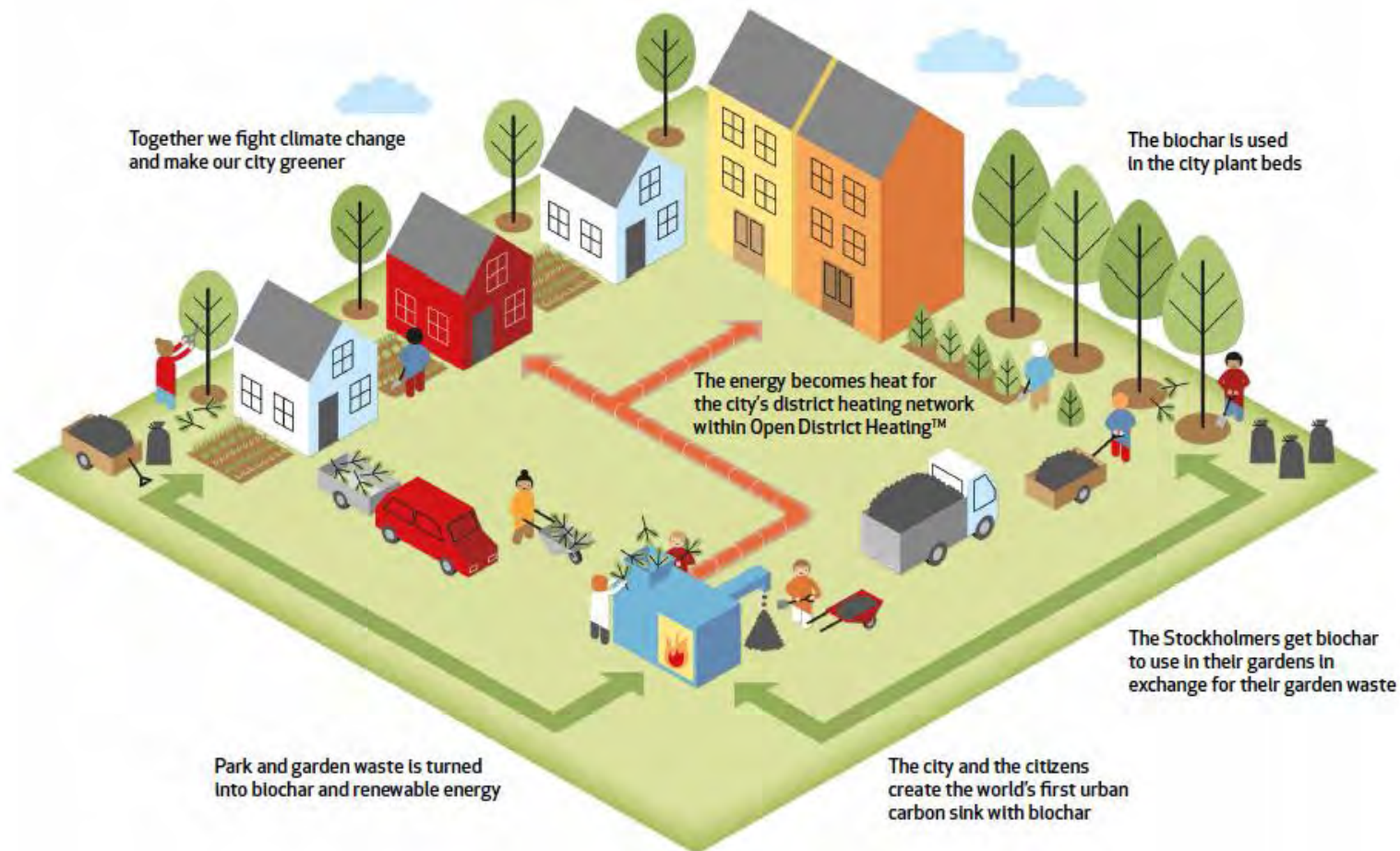


Photo: Christina Berger

Biochar and activated carbon filters for greywater treatment – comparison of organic matter and nutrients removal

Christina Berger

The world's first urban carbon sink with biochar. This is how it works!



Pilotanläggningen

ÅVC Trädgård i Högdalen

Förnybar värme till 80 lägenheter

Biokol motsvarande CO₂-utsläppen från 700 bilar

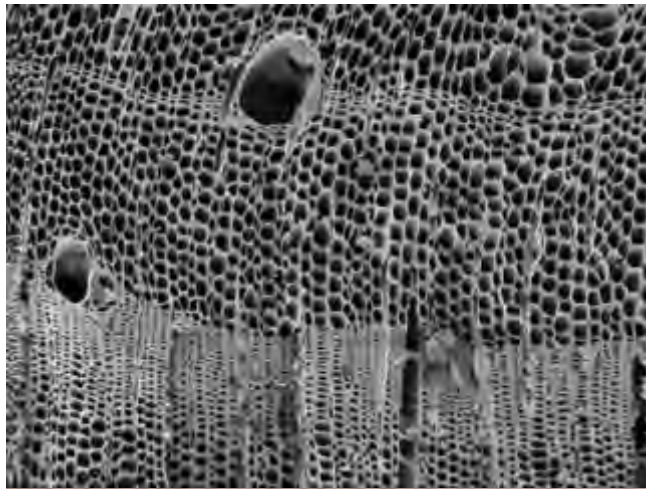
Projektets fullskala

Förnybar värme till 400 lägenheter

Biokol motsvarande CO₂-utsläppen från 3500 bilar







peat

About 500 000 tonnes of soil are sold every year in Stockholm
made of Sand Clay and Peat that are finite resources



clay



sand
gravel



from
esker



Biochar and stone chips = crushed granite 3parts (2-6mm) and nutrient-enriched biochar 1part.



Compost 1/8



Biochar 1/8



Macadam 6/8



Biochar and stone chips = crushed granite 6/8 volume (2-6mm) and nutrient-enriched biochar 1/8 volume
+ compost 1/8 volume





Biochar and stone chips = crushed granite (32-63 mm) and nutrient-enriched charcoal 15%. volume



indestructible soil
which can take
heavy loads without
being destroyed



Different fractions we use

Macadam $\frac{2}{6}$, $\frac{4}{8}$, $\frac{8}{11}$, $\frac{8}{16}$, $\frac{11}{16}$, $\frac{16}{22}$, $\frac{16}{32}$, $\frac{32}{63}$, $\frac{32}{90}$ $\frac{90}{150}$

Grass

Vegetables

Perennials

Shrubs

Trees



Kolonivägen 2016

Magnolias, Cersis, Prunus.

1 part biochar 0-10mm och 3 parts macadam 4-8 mm 600mm.











Haukadalsgatan kolgrus







Magnus Ladulåsgatan Stockholm

Biochar with infiltration of stormwater

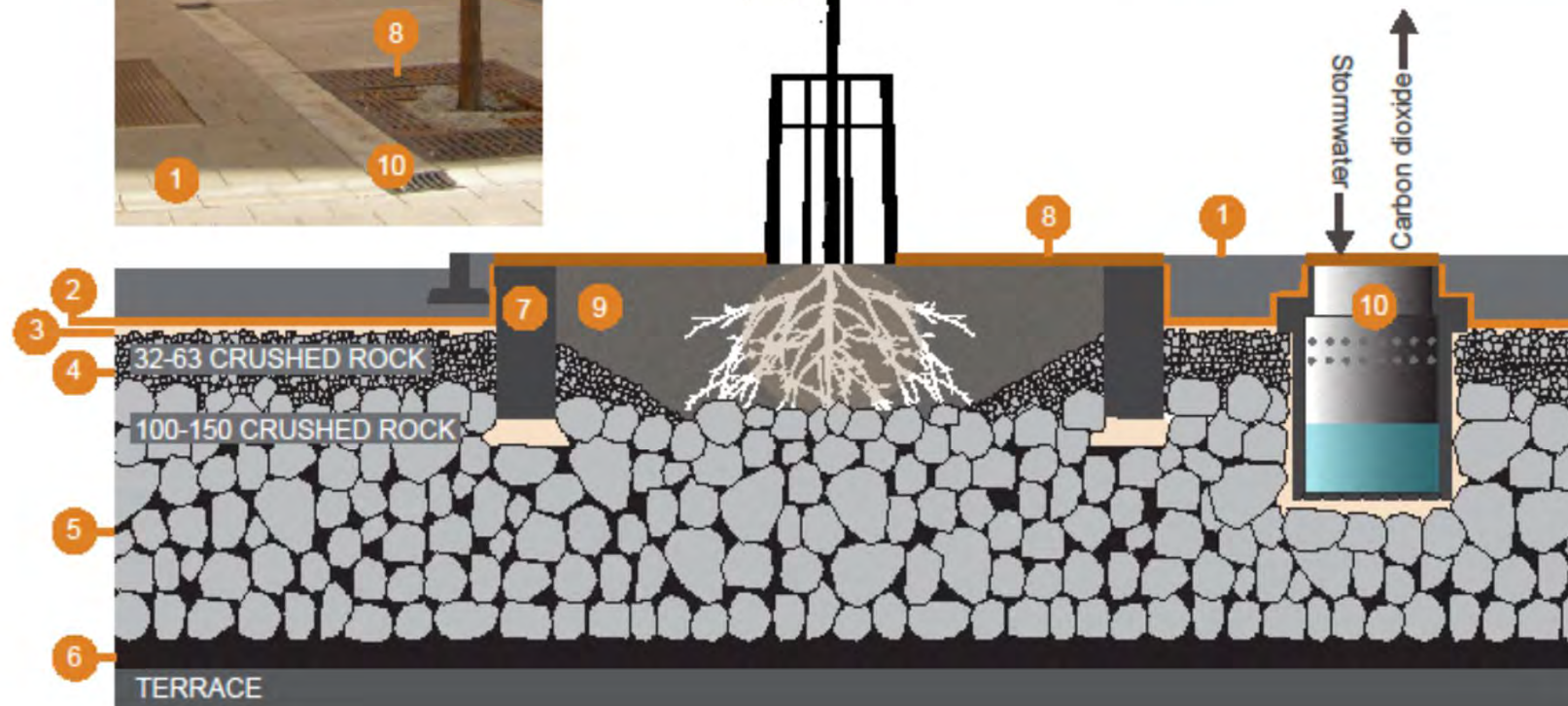
- Image # 1. Plant bed renovation a block of Magnus Ladulåsgatan where we follow our drawing 'structural soil with biochar'.
- The stone and biochar, Concrete box where the tree is planted,

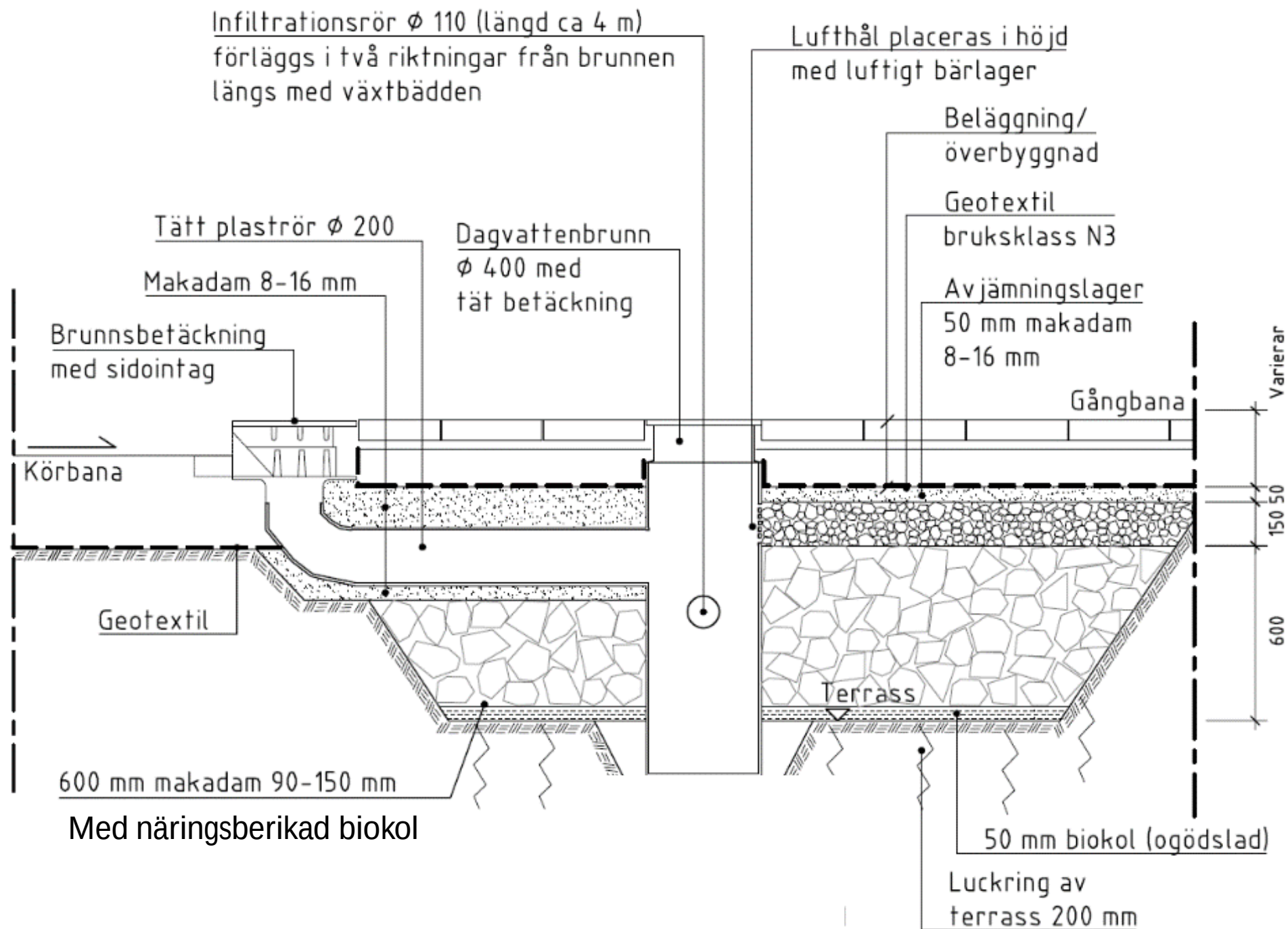
Structural soil with biochar

A method for building with stability and to create good growing conditions for trees in paved areas with the use of stormwater and the added value of decreasing the risk of roots damaging paving or underground pipes



1. Paved surface with dished stormwater gutters
2. Geotextile
3. Leveling layer (crushed rock 8-16 mm) – also used for concrete bunker and water/air inlet.
4. Aerated bearing layer (crushed rock 32-63 mm)
5. Structural soil (crushed rock 100-150 mm) with fertilized biochar hoed into the structural volume
6. Pure biochar on terrace
7. Concrete bunker
8. Surface grid
9. Crushed rock with fertilized biochar
10. Inlet for air and water supply









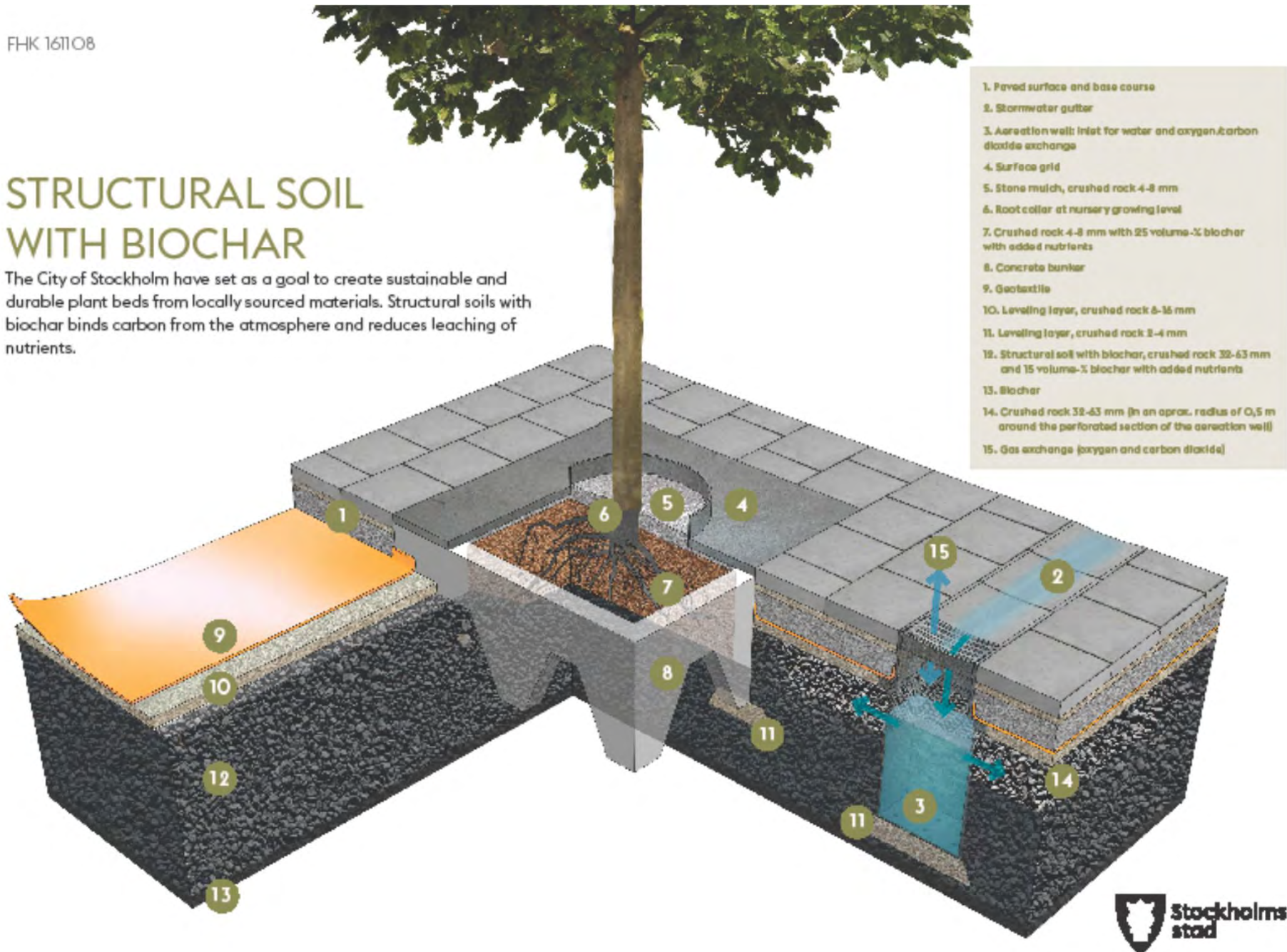
Nybrogatan Stockholm

Biochar with infiltration of stormwater

- Plant bed renovation a block of Nybrogatan where we follow our drawing 'structural soil with biochar'. Some of the old trees were saved.
- The stone and biochar are mixed before the material is laid down, 15% by volume biochar.
- Closest to the roots of saved trees added a mixture of crushed granite and 25% manured biochar.
- Concrete box where the tree is planted, in it you can see macadam mixed with 15% biochar

STRUCTURAL SOIL WITH BIOCHAR

The City of Stockholm have set as a goal to create sustainable and durable plant beds from locally sourced materials. Structural soils with biochar binds carbon from the atmosphere and reduces leaching of nutrients.



Nybrogatan 2015
Kolmakadam



Plant bed for street trees charcoal and macadam = crushed granite 32-63 mm mixed with 15% nutrient-enriched charcoal, granite can be replaced with recycled concrete with reinforcement (iron)



Nybrogatan 2015
Kolmakadam



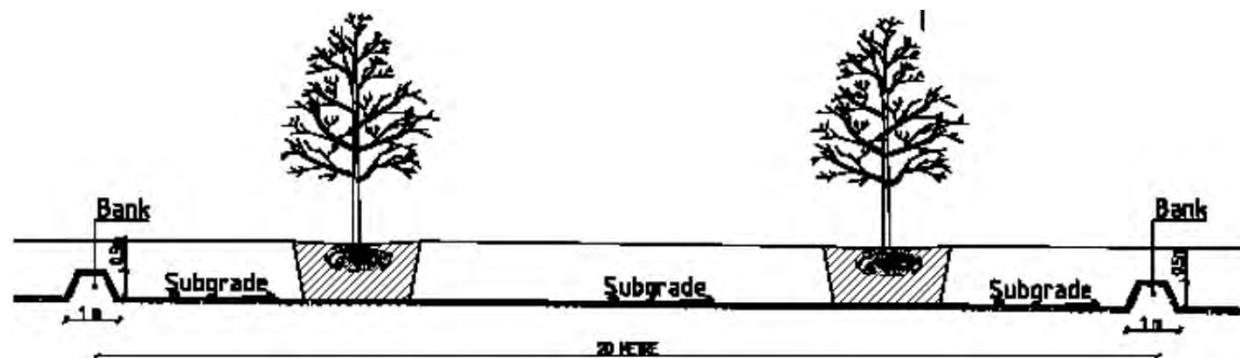


Nybrogatan 2016
Magnolia

Lingvägen

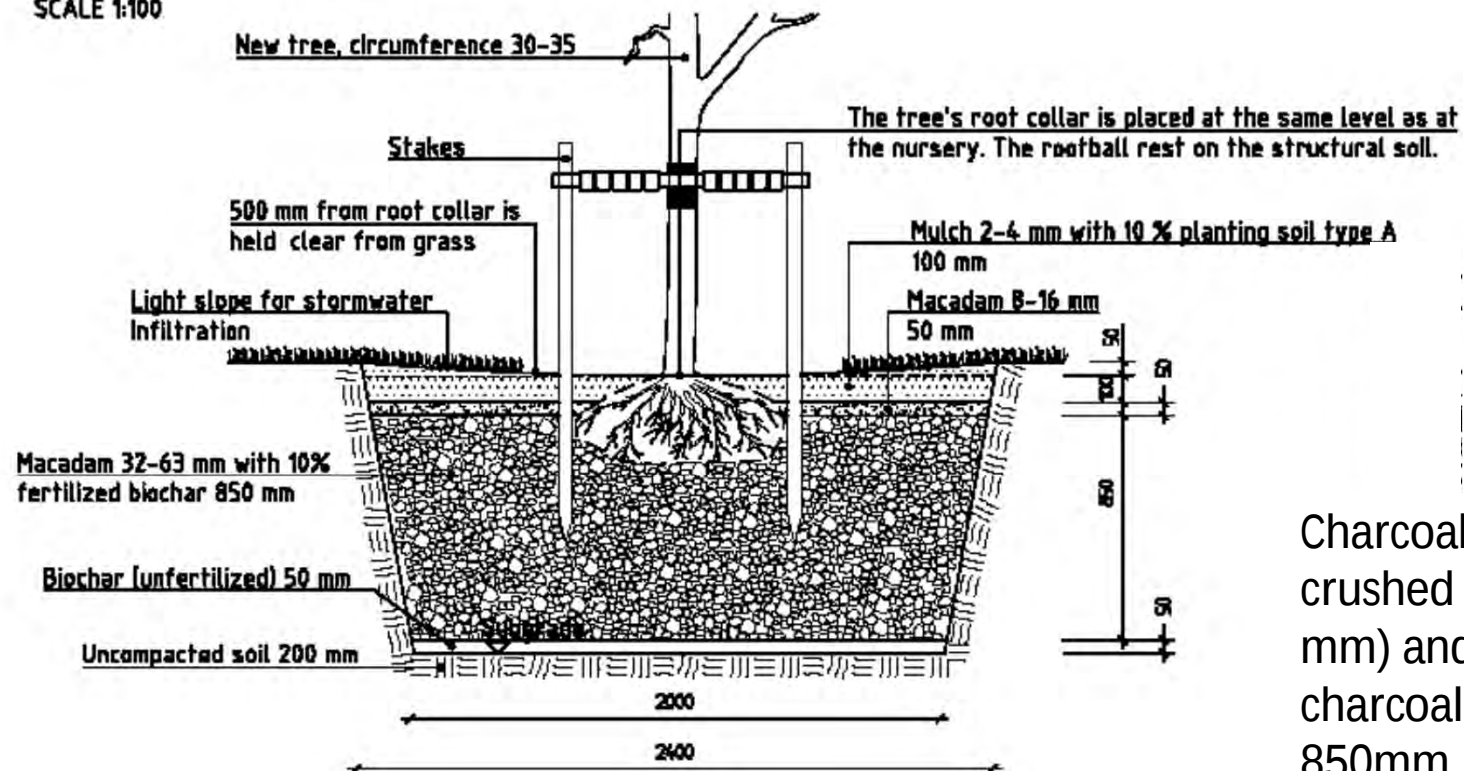
biochar with infiltration of stormwater

- Image # 1. Plant bed renovation a 600 meter by 2m wide and 1 m deep.
- Image # 2. where we follow our drawing 'tree pit with slanting subgrade'
- Image # 3. The ditch filled with biochar and gravel 8-16mm and a few months after planting



PLANTING PIT WITH SLANTING SUBGRADE

ELEVATION
SCALE 1:100



TREE PIT WITH BIOCHAR IN GREEN SPACE, TYPE 2

TYPE SECTION
SCALE 1:20

Drawing showing how we build plant bed for trees in the green area along streets and roads to maximize infiltration of storm water through a charcoal filter in the bottom of the plant bed where we catch up nutrients and pollutants.

Charcoal stone chips =
crushed granite (32-63
mm) and nutrient-enriched
charcoal 10/1. volume.
850mm

Plant bed for street trees charcoal macadam = crushed granite 8-16 mm mixed with nutrient-enriched charcoal



2014

Charcoalsoil
2-5 mm granit
depth 100 mm
Charcoalchips
8-16 mm granit
depth 900 mm

Maj 2015





Vallhallavägen

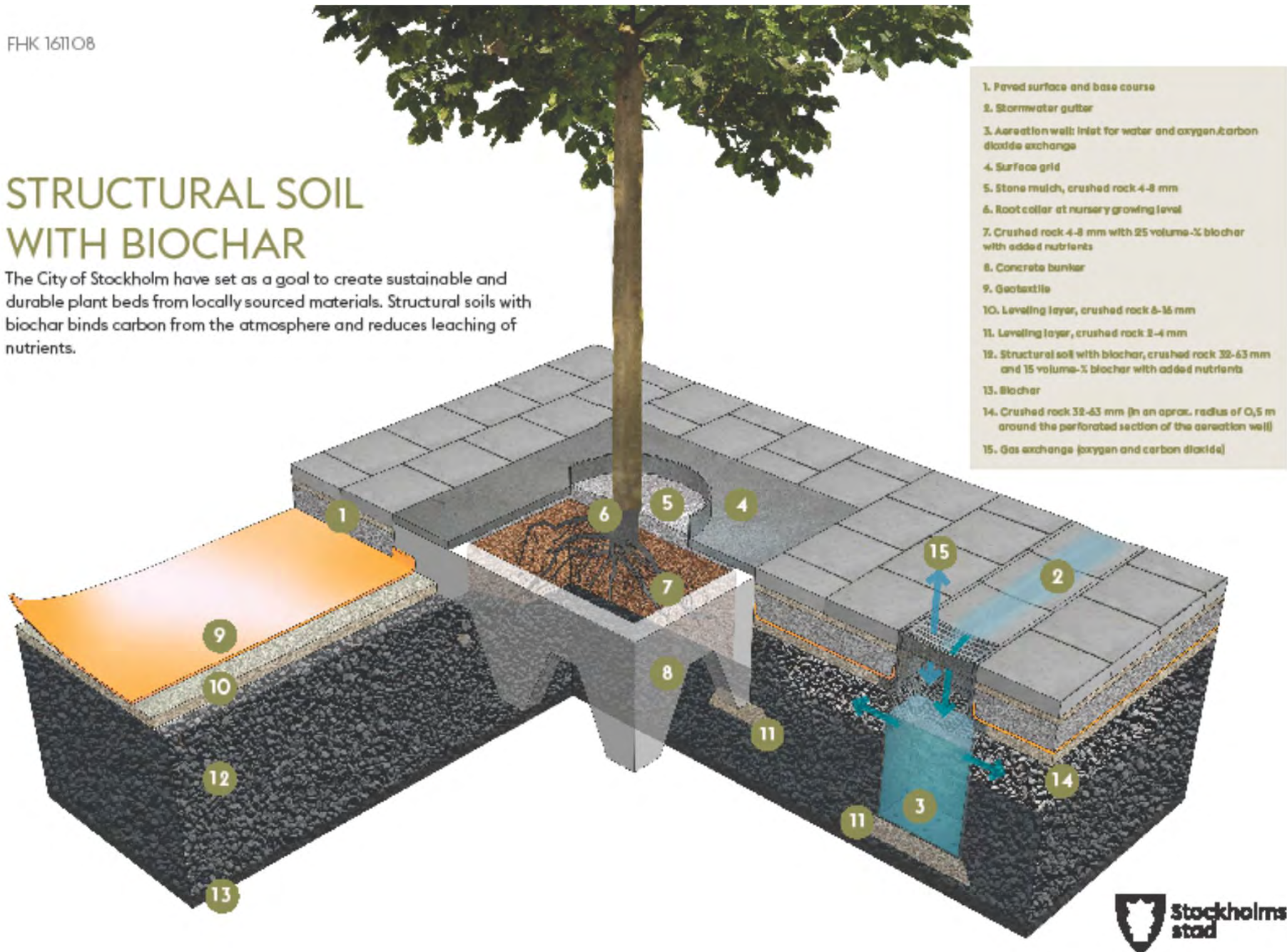
one hundred years old avenue of trees get

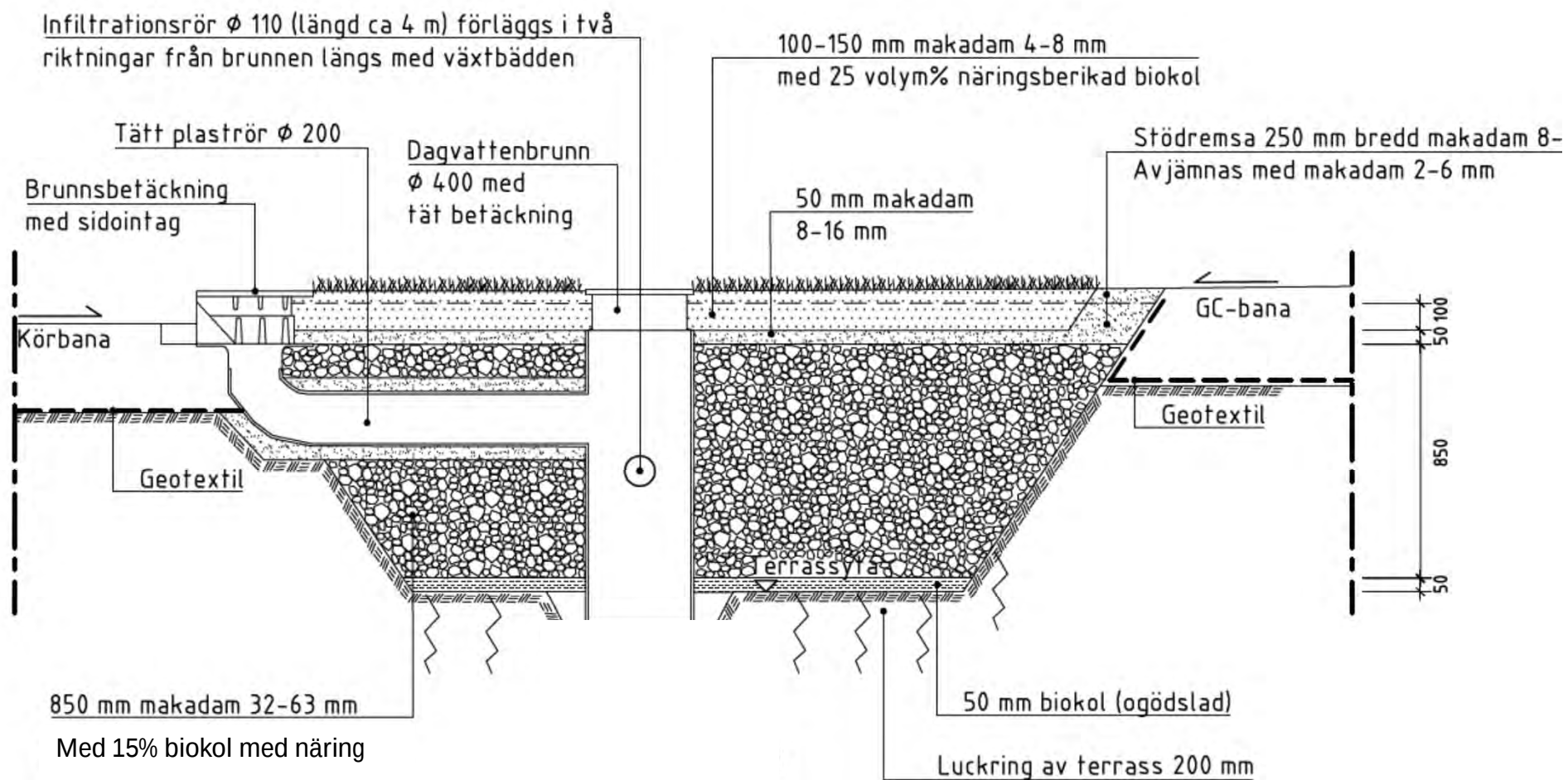
Biochar and macadam

- Compacted soil which is changed to ditch filled with biochar and macadam 32-63mm to save the trees with infiltration of stormwater
- the first time we sow grass on 2-6mm 3 parts 1 part biochar 100mm

STRUCTURAL SOIL WITH BIOCHAR

The City of Stockholm have set as a goal to create sustainable and durable plant beds from locally sourced materials. Structural soils with biochar binds carbon from the atmosphere and reduces leaching of nutrients.





DAGVATTENFÖRDRÖJNING - GRÄSYTA MED KOLMAKADAM

Valhallavägen





100mm mix of macadam 2-6mm 3 parts, 1 part biochar, and grass seed

8-16mm
30mm

32-63mm and 15% biochar
800mm

Valhallavägen
2016









2-6mm 3 parts 1 part biochar
100mm and grass seeds on the
surface







Pilgatan 2014

Biochar with infiltration of stormwater

Magnolias and perennials

1 part biochar 0-10mm and 3 parts crushed granite size 4-8 mm
800mm deep.



2014/12/04

Biochar and stone chips = crushed granite 3/4 (2-6mm) and nutrient-enriched charcoal 1/4. volume



Biochar and stone chips = crushed granite 3/4 (2-6mm) and nutrient-enriched charcoal 1/4. volume



the material acts as an open magasin able to receive storm water to at least 30% of its volume

2017 augusti



2017 augusti

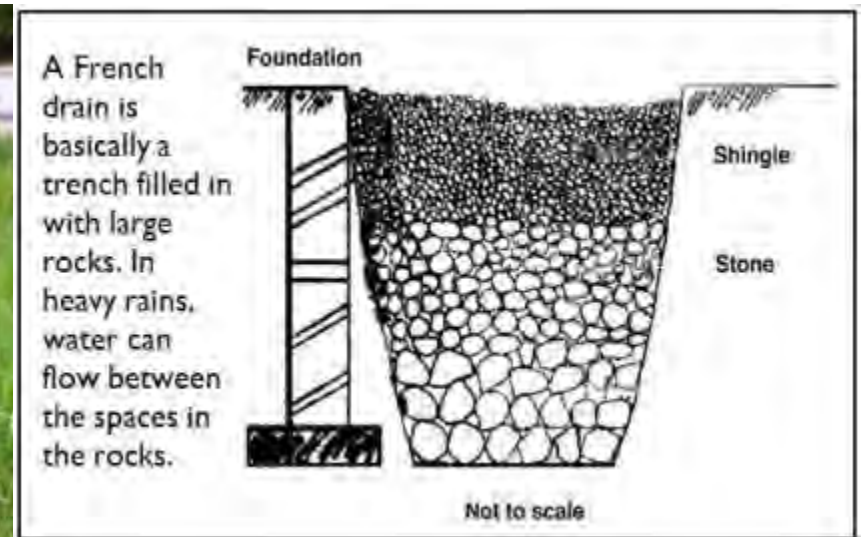


10 000 cherry trees

macadam 8-16mm
10% biokol 0-10mm

700mm deep
150mm wide





our trenches has a mixture of
1 part biochar
9 parts 4-8 mm crushed granite

mykorrhiza





Helsingborg
Drottninggatan

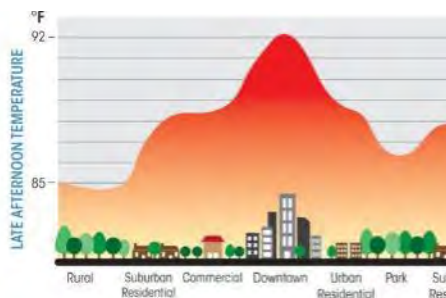
Uppsala 2017



Reduce the risk of floods



counteract the heat island effect



Reduce the presence of particles and carbon dioxide in the air



Reduce the load on the storm water systems, thereby reducing pollution in Lake Mälaren and the Baltic Sea



300mm deep, = crushed granite 6/8 volume parts (2-6mm) and nutrient-enriched biochar (50%) + compost (50%) 2/8 volume parts
Magnolia tripetala



Magnolia tripetala





300mm deep, = crushed granite 6/8 volume parts (2-6mm) and nutrient-enriched biochar (50%) + compost (50%) 2/8 volume parts
Lettuce artichoke potatoes







2017
First potatoes grown in
macadam biochar and
compost

<http://www.stockholm.se/trad>

http://www.stockholm.se/PageFiles/153375/V%C3%A4xtb%C3%A4ddar_i_Stockholm_2017_.pdf



Växtbäddar i Stockholms stad

– en handbok 2017

[stockholm.se/trad](http://www.stockholm.se/trad)

Benefits of Soil Best Practices

For Builders, Developers, and Landscape Contractors • Better landscape appearance = happier customers, which sells the next job

- Better erosion control
- Better stormwater management
- Easier, faster planting in amended soil
- Much better plant survival (fewer callbacks for dying plants and lawns)

For Property Owners • Easier, cheaper landscape maintenance

- Up to 50% less summer irrigation needs
- Lower fertilizer needs
- Much less pesticides and herbicides needed – easier, and healthier for families
- Better landscape appearance, all year 'round

For Our Waterways, Salmon, and Other Wildlife

- Reduced stormwater runoff = less erosion and sediment in salmon streams
- Increased groundwater recharge = better summer stream flows
- Less demand for irrigation water supply = more water in rivers for wildlife
- Bio-filtration of urban pollutants (running through compost-amended soil filters out 60-95% of contaminants)
- Less need for fertilizers and pesticides, so less washing off into streams

<http://www.soilsforsalmon.org/why.htm>

<http://www.soilsforsalmon.org/how.htm>

[https://www.gov.uk/government/publications/
working-with-natural-processes-to-reduce-
flood-risk](https://www.gov.uk/government/publications/working-with-natural-processes-to-reduce-flood-risk)

[https://ilsr.org/wp-
content/uploads/2013/05/Compost-Builds-
Healthy-Soils-ILSR-5-08-13-2.pdf](https://ilsr.org/wp-content/uploads/2013/05/Compost-Builds-Healthy-Soils-ILSR-5-08-13-2.pdf)