Notes on a UK water market demonstration

Google Maps.

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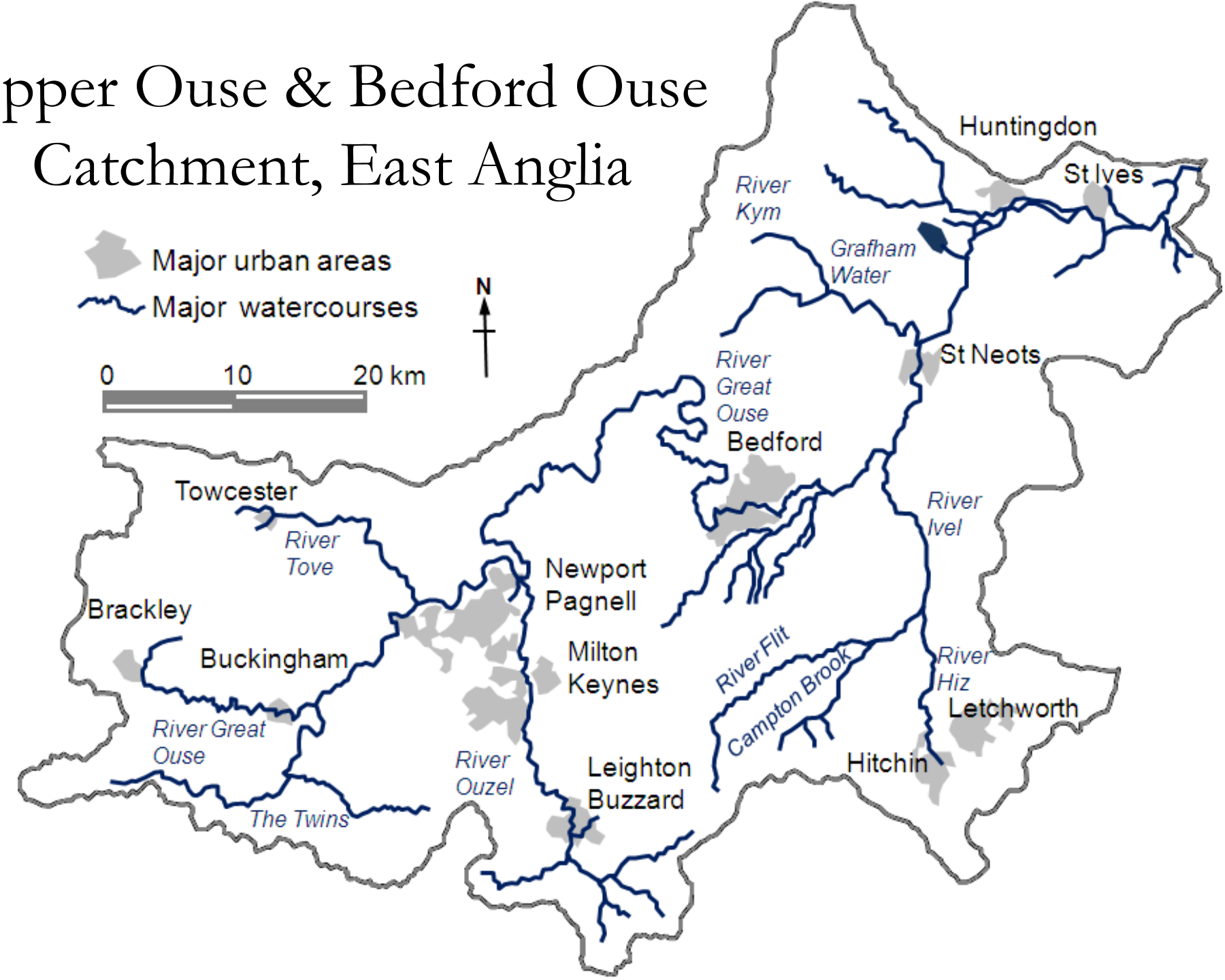
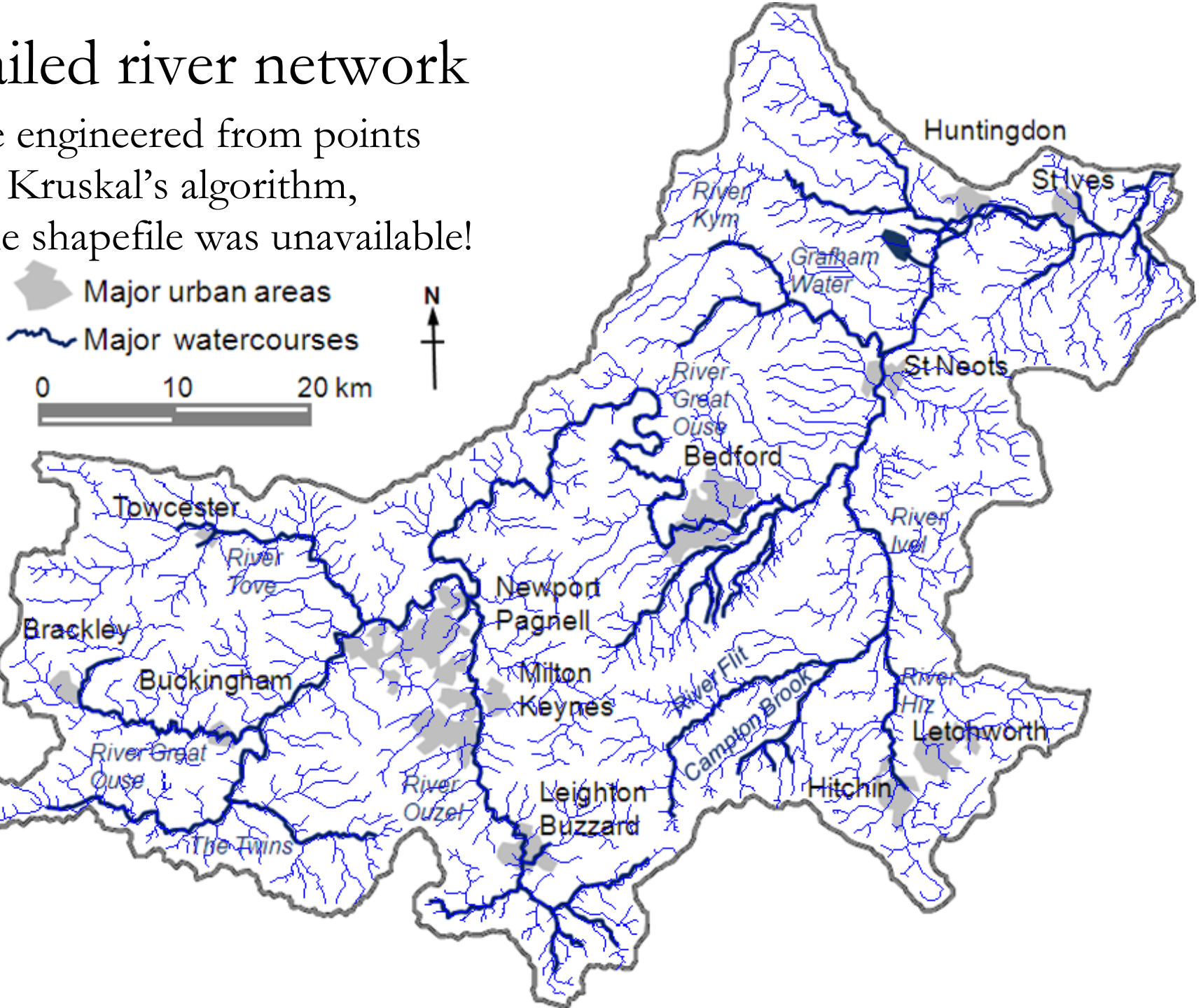
I. Development: LP, key scripts, complications.
II. Users' reactions, price-finding process, change in mindset.
III. Demo a smart market for water, East Anglia.
Part of a large set of projects to reform UK water licensing.

Upper Ouse & Bedford Ouse Catchment, East Anglia

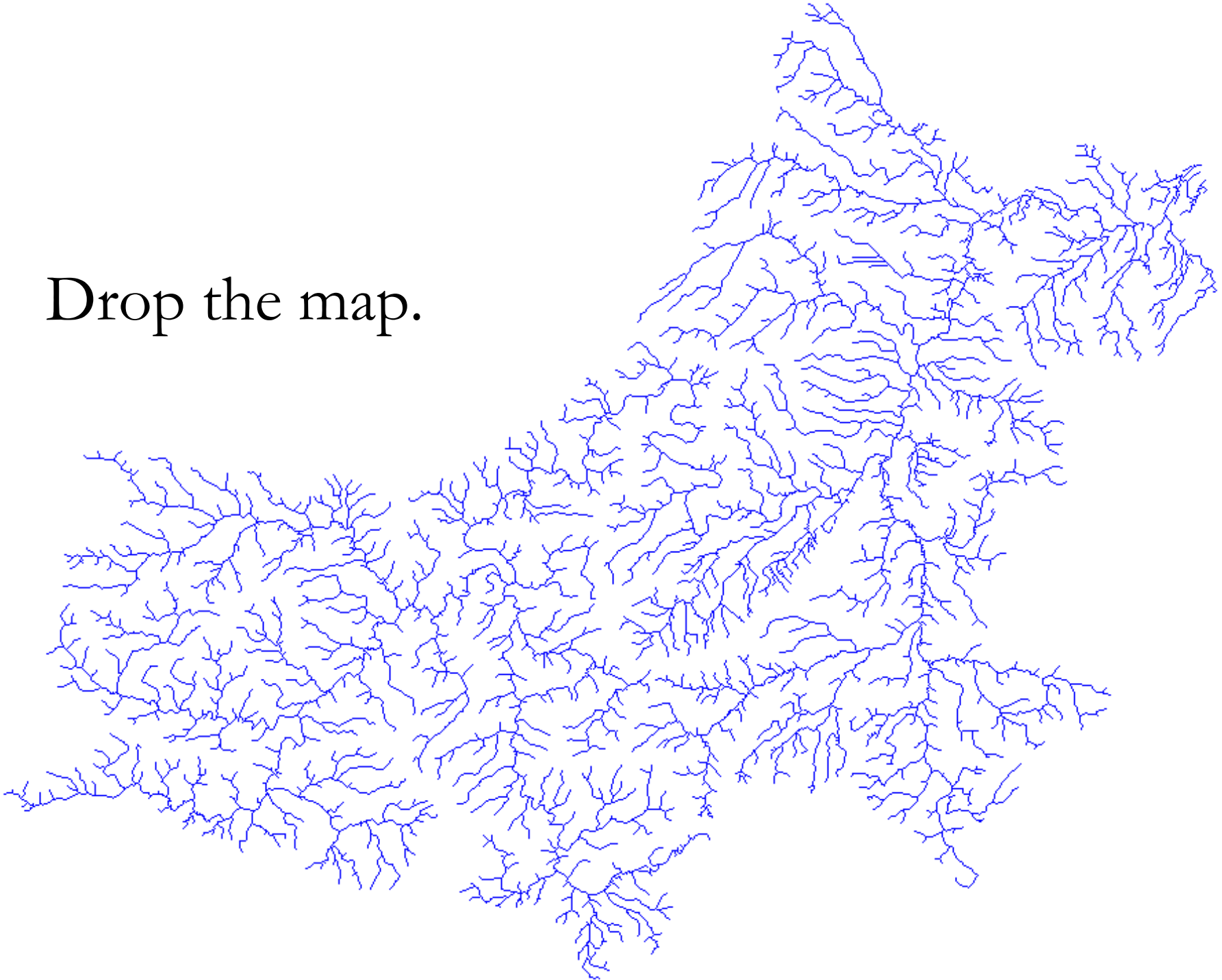


Detailed river network

Reverse engineered from points
with Kruskal's algorithm,
as the shapefile was unavailable!



Drop the map.

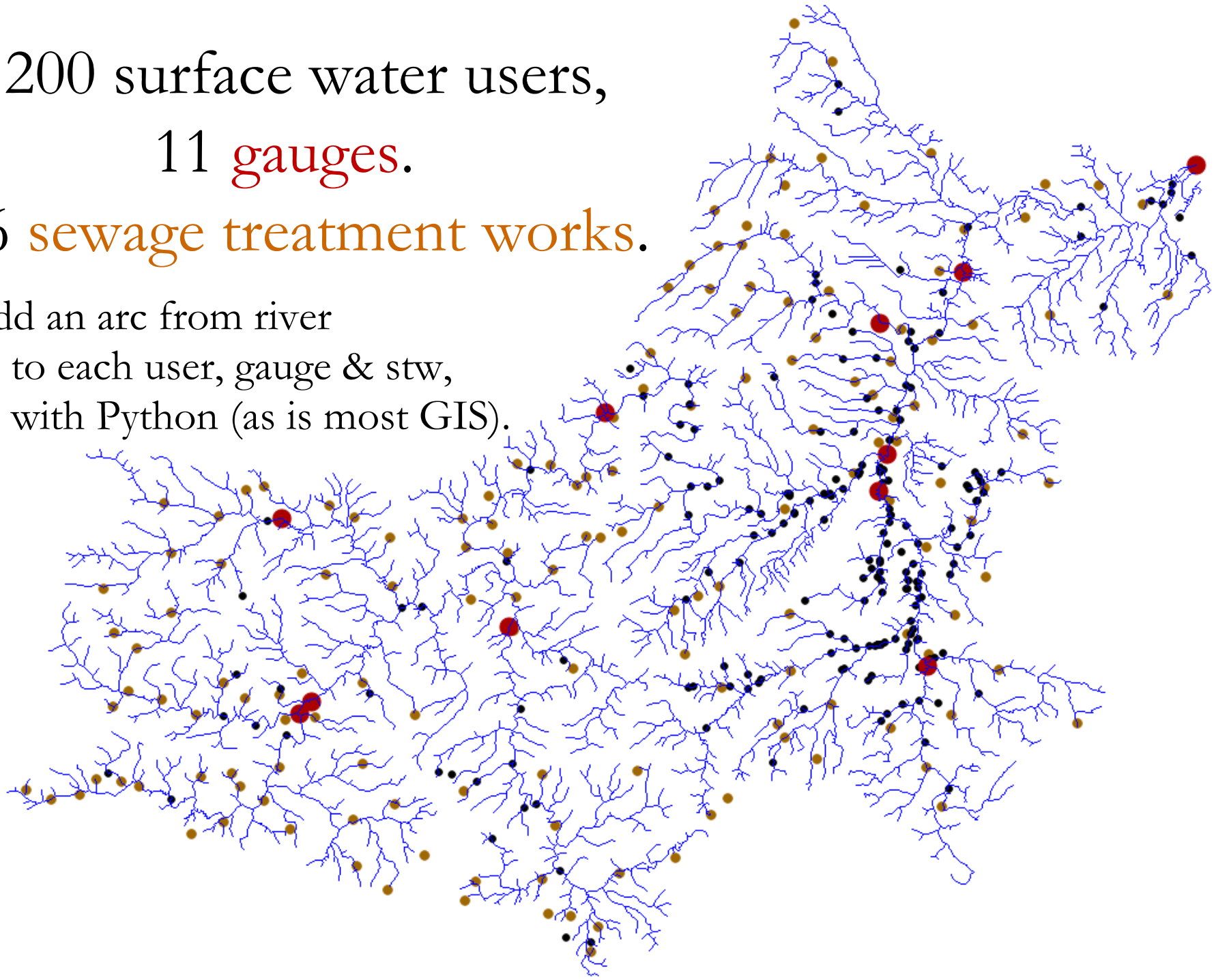


~200 surface water users,

11 gauges.

156 sewage treatment works.

Add an arc from river
to each user, gauge & stw,
with Python (as is most GIS).



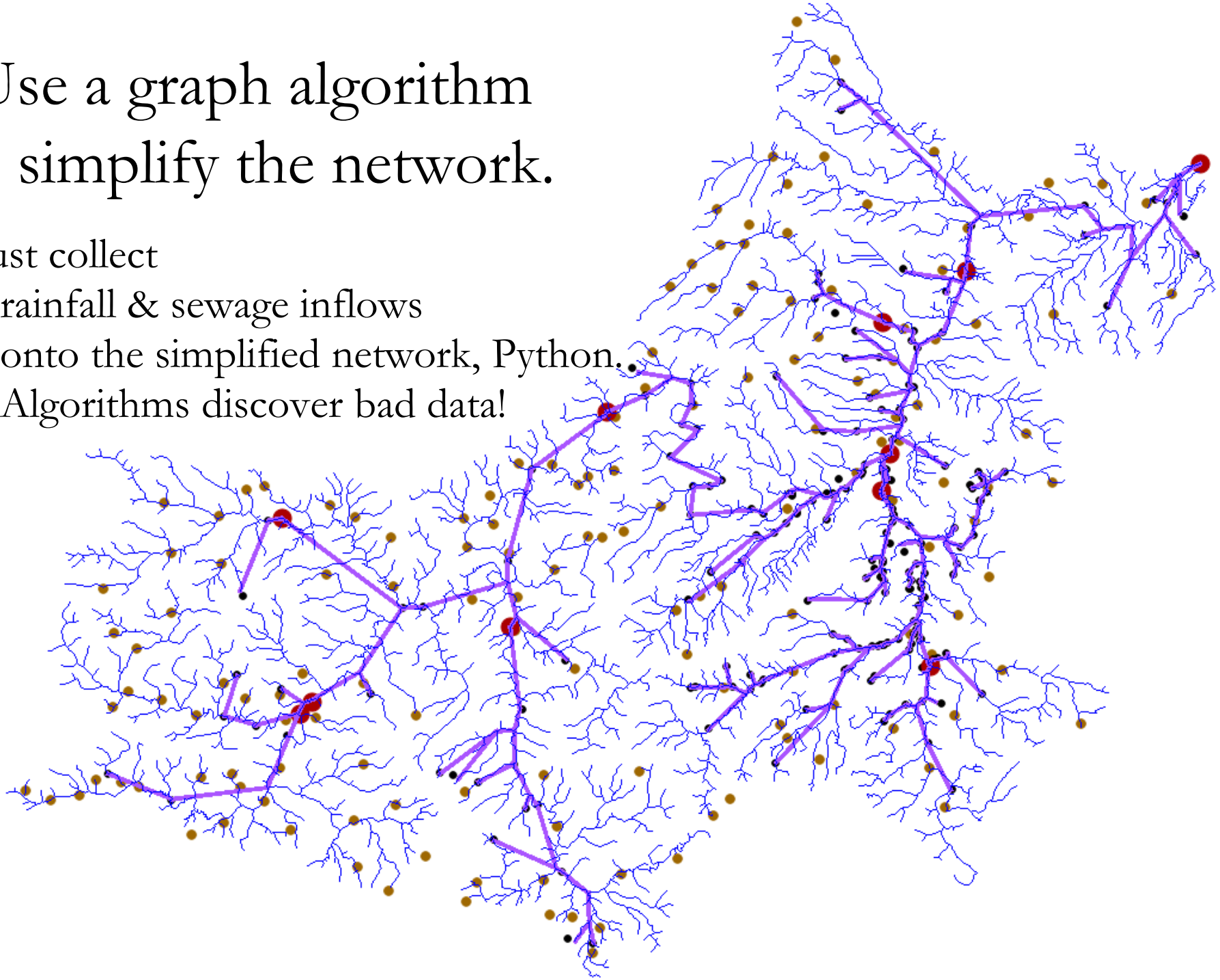
Use a graph algorithm to simplify the network.

Must collect

rainfall & sewage inflows

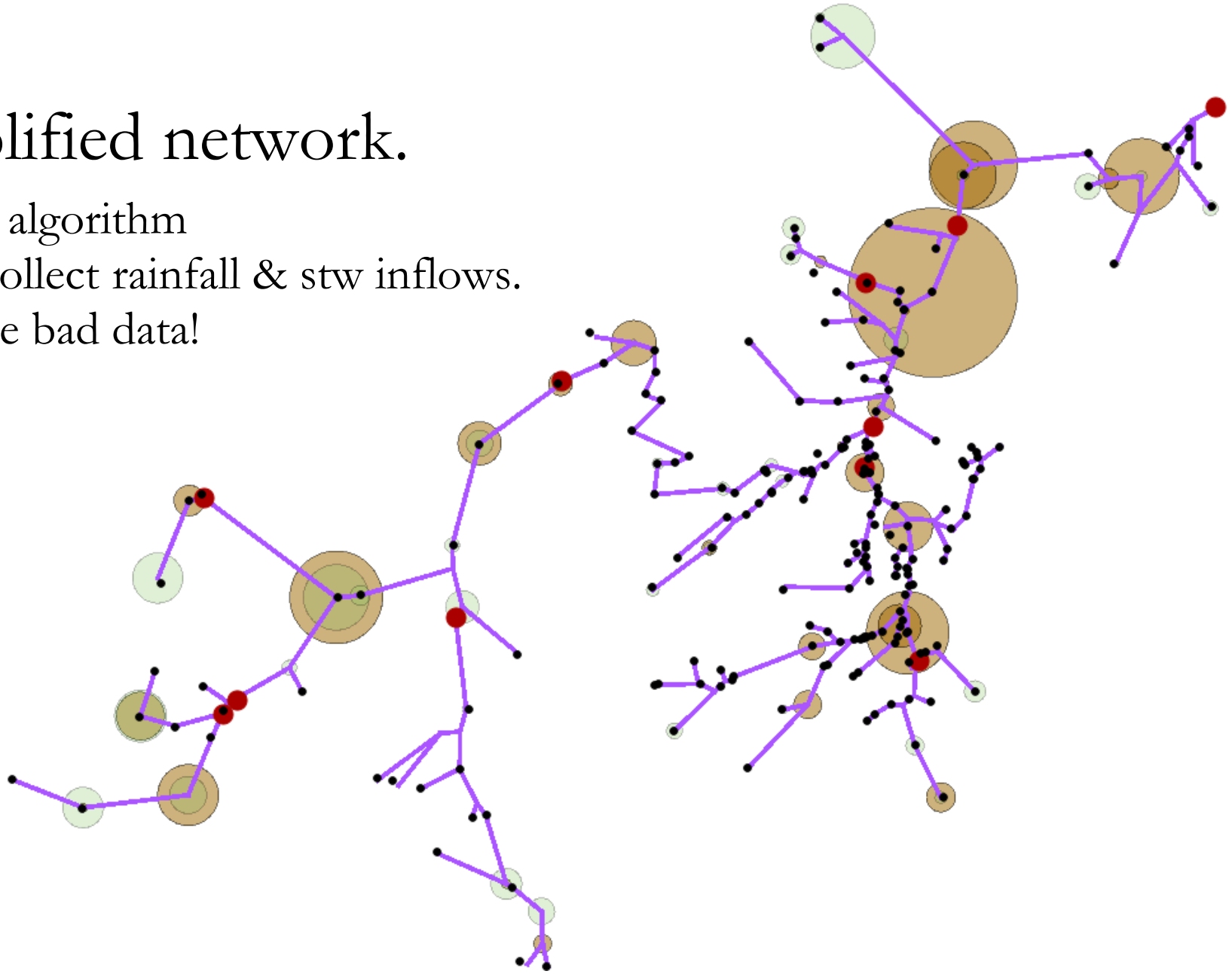
onto the simplified network, Python.

Algorithms discover bad data!



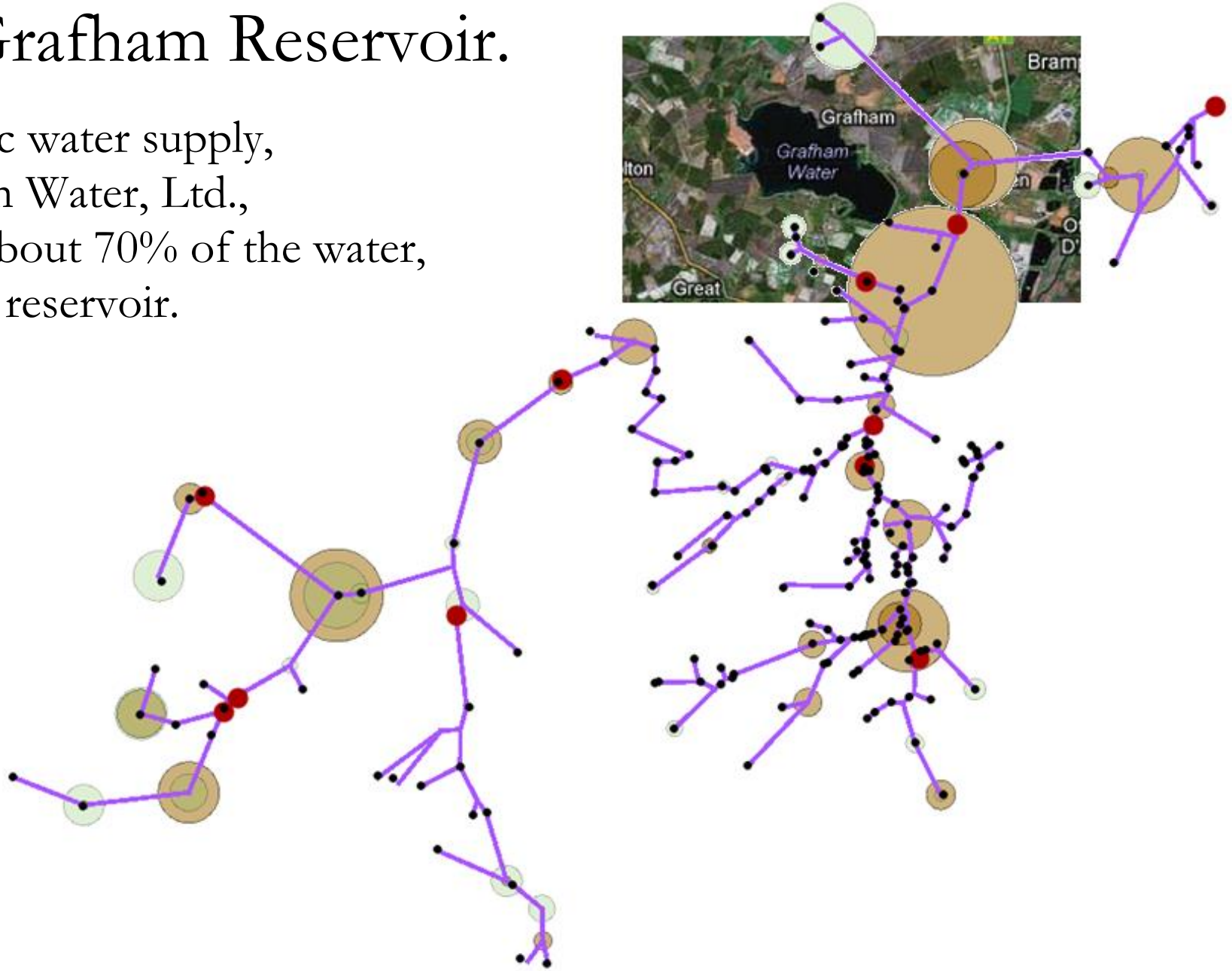
Simplified network.

Graph algorithm
to collect rainfall & stw inflows.
Manage bad data!



Add Grafham Reservoir.

The public water supply,
Anglian Water, Ltd.,
takes about 70% of the water,
via the reservoir.



Gross pool market-clearing LP

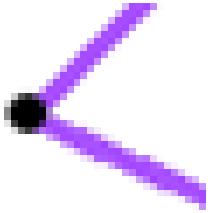
Max $\sum_{\text{bids } b} \sum_{\text{users } w} \sum_{\text{weeks } t} BidPrice_{b,w,t}\, bid_{b,w,t}$

Limit each tranche b, user w & week t: $bid_{b,w,t} \le BidQty_{b,w,t}$

Allocation = total for each user w & week t: $q_{(j,w),t} = \sum^{5}_{b=1} bid_{b,w,t}$, price $price_{w,t}$

Mass balance at each node j & week t:

$$Inflow_{j,t} + \sum_{\text{arcs } i,j:\, i \notin Head} flow_{i,j,t} - \sum_{\text{users } w} q_{(j,w),t} = \sum_{\text{arcs } j,k} flow_{j,k,t}$$



Required env flows for each gauge j & week t:

$$Inflow_{j,t} + \sum_{\text{arcs } i,j:\, i \notin Headwater} flow_{i,j,t} - \sum_{\text{users } w} q_{(j,w),t} \ge \min(MinFlow_{j,t}, Inflow_{}$$

Grafham Reservoir for each week t:

$$glevel_{t-1} + Inflow_{\text{Grafham},t} + q_{(\text{River,Grafham}),t} - \sum_{\text{users } w} q_{(\text{Grafham},w),t} = glevel_t$$

$$glevel_t \le Gcapacity$$

$$glevel_1 = glevel_T$$

~200 users, 52 weeks, 25k rows, 78k vars. Solve with Python & PuLP, 90 secs.

Initial rights & default bids.

Convert each user's annual license
to weekly initial quota,
based on the user's average use.

Created default bids
by season & type of user (farm, hydropower, ...).

Little data on value of water!
Aus water market Au$8/ML,
UK public supply £250/ML non-potable for industrial users.
UK public supply £1,100/ML potable.

So what's the price?

Next: demo.

Demonstration (draft web site)

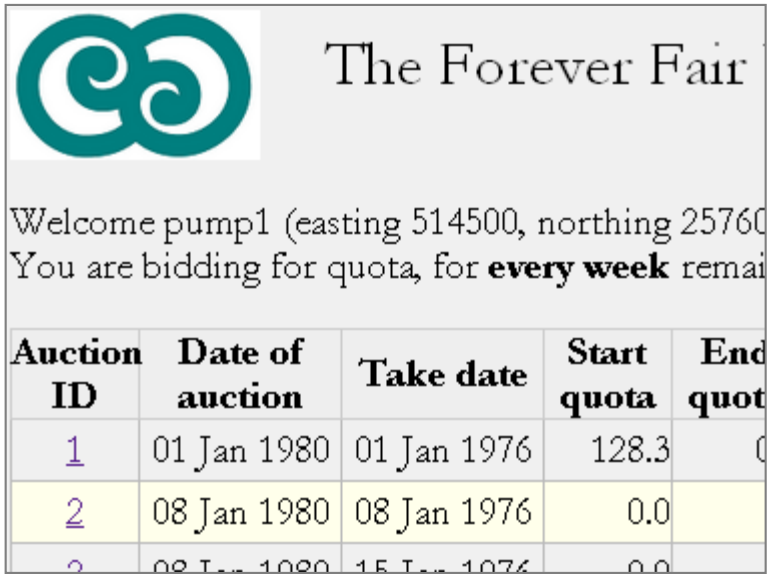
Auction Manager page.

- Controls market clearing.
- Each auction extends from current week through week 52:
  1 to 52, 2 to 52, 3 to 52, …, 51 to 52, then 52 alone.
  Most users will bid only in summer.
- Ability to set "dummy" bids for all users.

User bidding page.

- Initial quota will be scaled.
- Bid for each future week's water in tranches (servings).

Next: visualization.


The Forever Fair

Welcome pump1 (easting 514500, northing 25760
You are bidding for quota, for **every week** remai

Auction ID	Date of auction	Take date	Start quota	End quot
1	01 Jan 1980	01 Jan 1976	128.3	
2	08 Jan 1980	08 Jan 1976	0.0	

What happened in the demo?

Users were intimidated by the web page.

- Confused by units, m^3/day versus ML/week.

Users had no idea what to bid.

- Price-finding process had no history.

Users do not want a gross pool interface!

- Afraid of "losing their water".
- Multi-part bids are too complicated.
- They want "buy" and "sell" buttons.

Changes needed in mindset

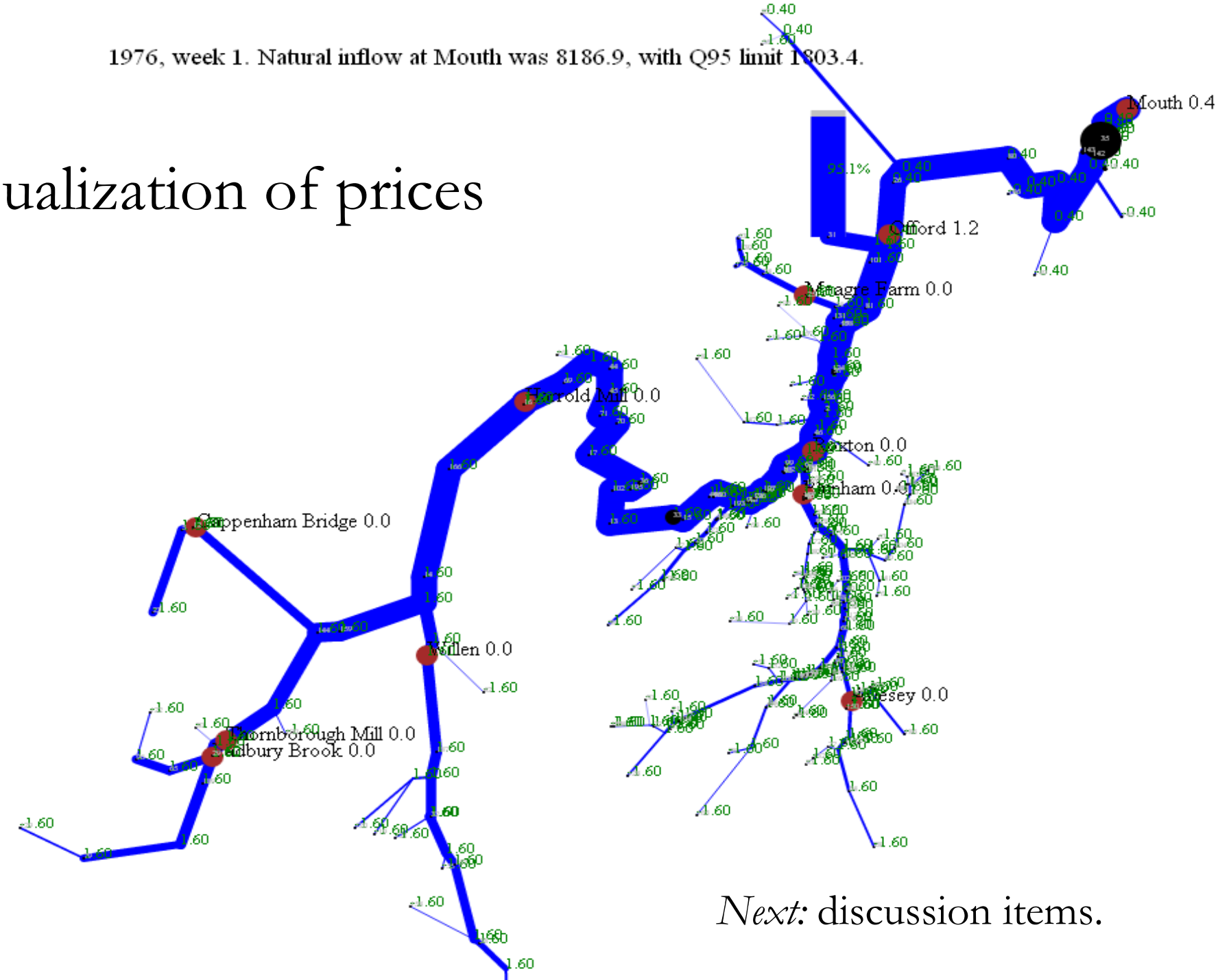
#1. Speed & precision. Trading happens every week!
Rivers flows & user abstractions near predicted values.

#2. Users trade **quota**, a rental by week.
Bid for a **schedule**, with bids for future weeks.
Weeks 25 & 26 have different prices.

#3. Quota will be scaled **by week** to adjust to inflows by week, to ensure the market manager's revenue neutrality.

#4. Gaining from trade takes effort.
Hours of analysis to do it well.
Changing every week.
More effort brings more gains.

Visualization of prices



Next: discussion items.

Issues for further discussion, esp. AW

AW is likely a price setter.
- But little market power due inelastic demand.

AW provides services to farmers!
- Injections of STW:
  - simultaneous buy at one point, sell at other points.
  - Tends to moderate prices?
- Reservoir smooths prices by period.

AW "taking water from farmers" –
- but farmers would get paid.
- Probably a more nuanced situation.

Should AW or market operator manage the reservoir?
- Affects market operations (single versus multi-period).

Easy to add an environmental buyer, e.g., Bird Society. *[End]*