water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

SOME HYDROLOGICAL CONSIDERATIONS FOR THE SPATIAL REVIEW OF THE NATIONAL WATER RESOURCES MONITORING NETWORK

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Acknowledgements

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- DWS: RQIS
- DWS: IWRP
- All DWS Regional Office
- >100 people providing input to process

Presentation Objectives

- **DWS Network Review Project**
- Reminder of the **network review process**.
- Describe **theoretical spatial criteria used for**
  - **Hydrological Considerations**
  - **(Geo-hydrological Considerations)**

Review, evaluation and optimisation of the National Water Resources Monitoring Networks Project

Aim to:

- undertake an **evaluation of each the 10 monitoring** networks in their **present condition**,
- **redesign and realign** (where necessary) the networks with the **strategic and management requirements of the DWS and SA**,
- **optimise the networks** as far as possible, and
- ensure **sustainable, relevant and up-to-date data of an acceptable quality**.

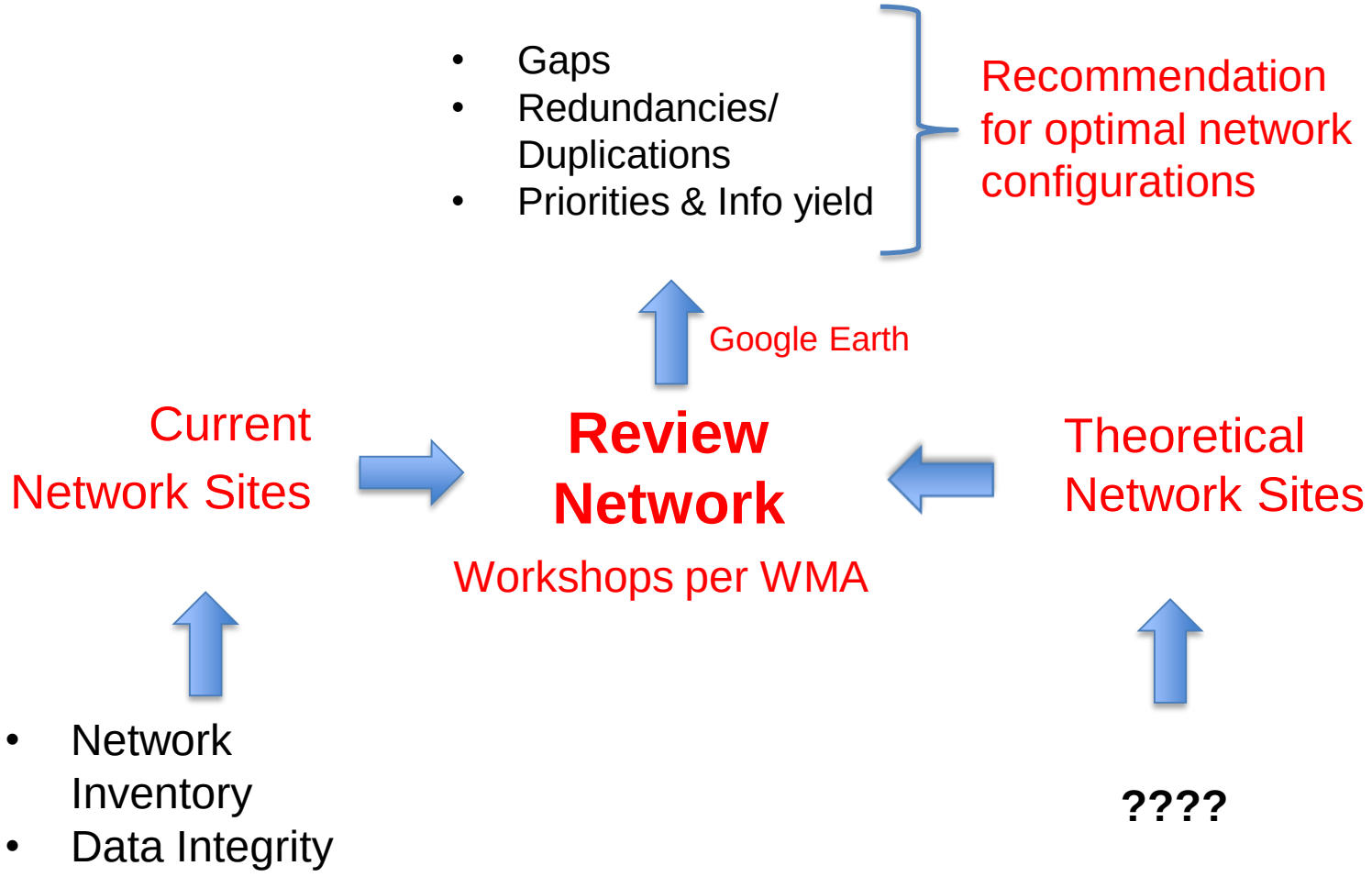
Outcome:

National Water Resource Monitoring Implementation Strategy

Redesign, realign and optimise.

- Extensive process undertaken to **get status quo of current monitoring** activities and integrity of data
- Require **independent way of evaluating existing network** to assess adequacy of meeting of DWS needs.
- What are the **objectives** of a national water resources monitoring network?
- Who are the **main clients**?
- **Where and what** should we be measuring?

National Network Spatial Review Process



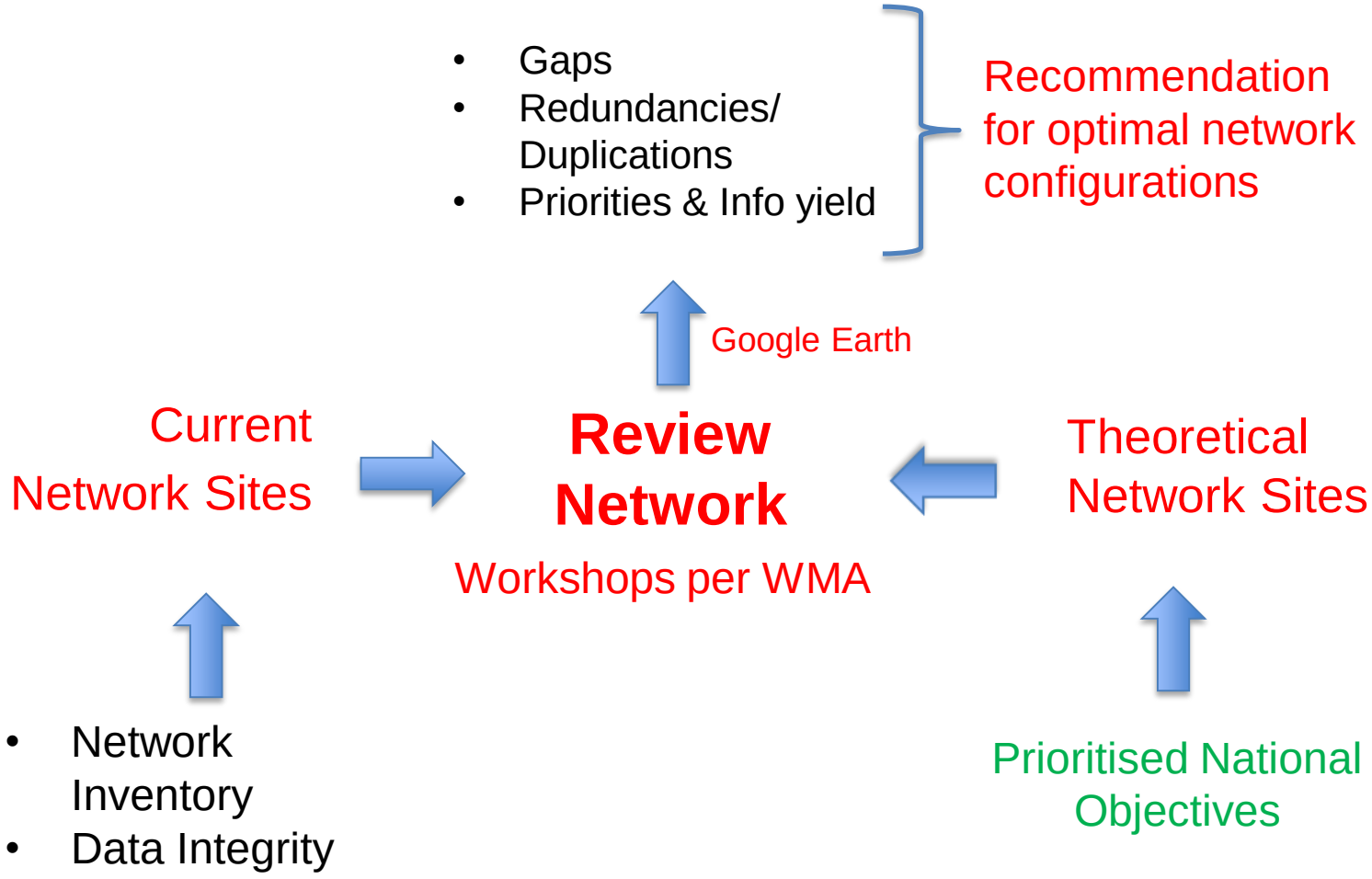
Theoretical Water Resources Monitoring Network.

- A chance for a **new beginning**.
- Totally **independent** of current monitoring activities.
- Take **no constraints** into account (except the physical impossible)
- Would be **Theoretical Optimal Network** that would **meet all DWS: WIMs legal and other requirements to monitor water resources nationally.**

National Water Resource Monitoring Objectives

Priority class	Objective	Description
1	Resource and infrastructure planning	To provide adequate monitoring data for determining the availability and quality of current and future water resources, aimed at providing strategic decision support for the equitable and sustainable allocation of resources to the population, environment and other economic sectors of society through planned infrastructure development and other interventions.
2	Resource operations and management	To provide timely monitoring data for the efficient operation and management of water resources to ensure the protection of resources and water users and to allocate water equitably and sustainably.
3	Warning systems	To provide timeous water resources monitoring data for early-warning systems to mitigate negative impacts on humans, infrastructure, the economy and riverine and coastal ecosystems.
4	Compliance and auditing	To provide water quality and quantity monitoring data to ensure compliance and auditing functions required for water use licensing, and other functions.

National Network Spatial Review Process



Development of a theoretical monitoring network

Why monitor?
What has priority?

→

Where should we monitor?
What and how often?

National Water Resources Monitoring Objectives ✓✓

↓

Legal and Scientific Processes to meet needs

→

Spatial monitoring criteria to support legal/scientific processes

Theoretical Monitoring Sites

↑

National Spatial Datasets

Sub-objectives and processes

Main objective	Sub-objective	Process
Resource and infrastructure planning	Quantify available resource	Rainfall-runoff modelling
		Groundwater modelling
		International obligations
		Research and baseline catchments
		Reserve requirements
		Estuarine requirements
	Determine fitness for use of resources	Quality trend and threshold analyses
		Salinity modelling
		Eutrophication modelling
		Groundwater modelling
	Development options analysis system operating rules	Water resource systems modelling, including demand projections
	Infrastructure design	Sediment analysis
		Flood analysis

Development of a theoretical monitoring network

Why monitor?
What has priority?

→ Where should we monitor?
What and how often?

National Water Resources Monitoring Objectives ✓✓

↓

Legal and Scientific Processes to meet needs ✓✓

→ Theoretical Monitoring Sites

National Spatial Datasets ↑

Spatial monitoring criteria to support legal/scientific processes

Placement of theoretical monitoring site

The following groupings of **considerations for site placement** relative to spatial datasets were used:

- Hydrological/Geo-hydrological
- Ecosystem
- Anthropogenic

Hydrological Criteria

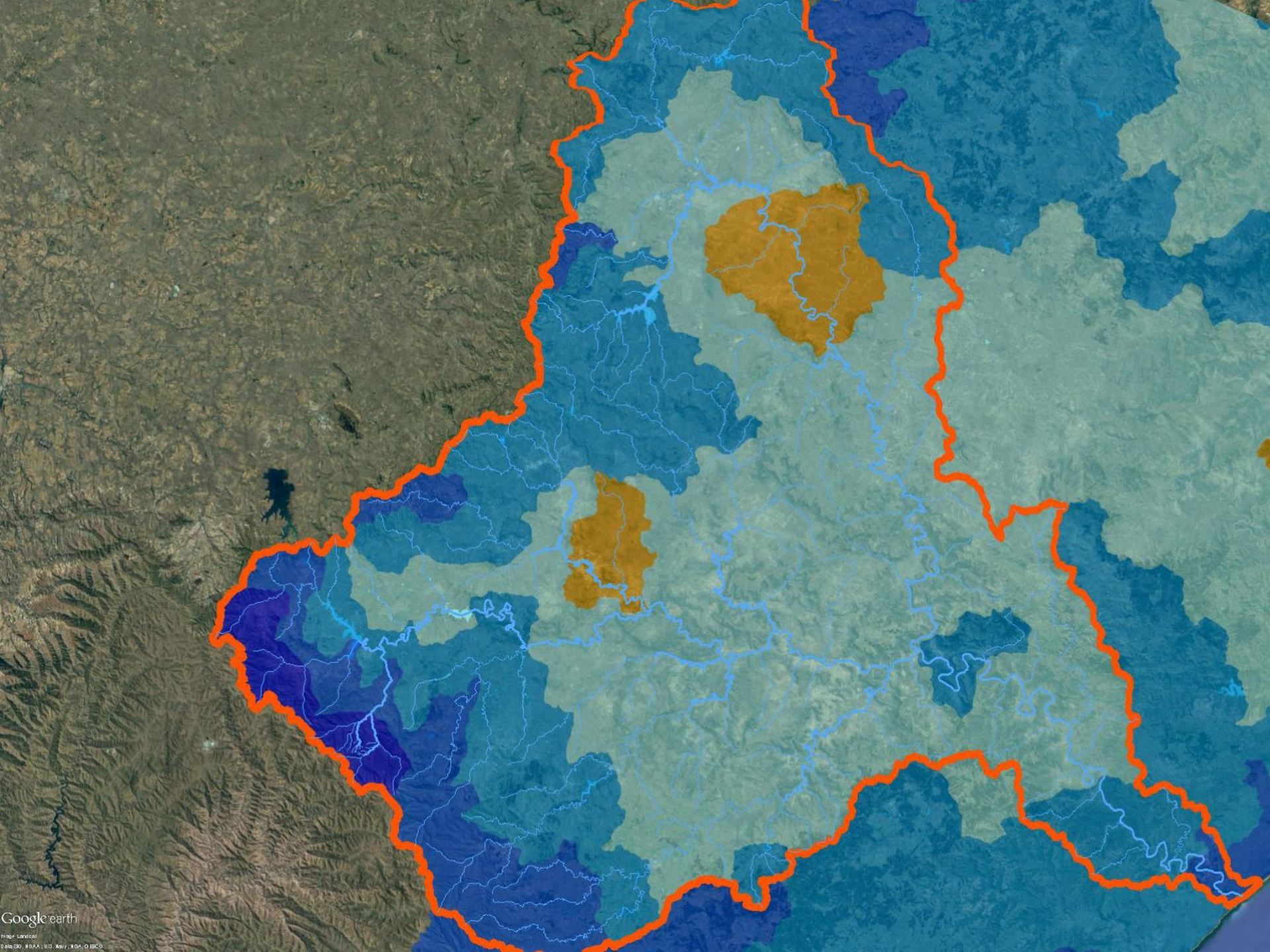
Based on **natural characteristic** of each primary/secondary basins:

- **Location of high runoff** areas
- **Distribution** of total flows per quaternary
- **International obligations**

All based on WR2012 Data and “national catchment tree”

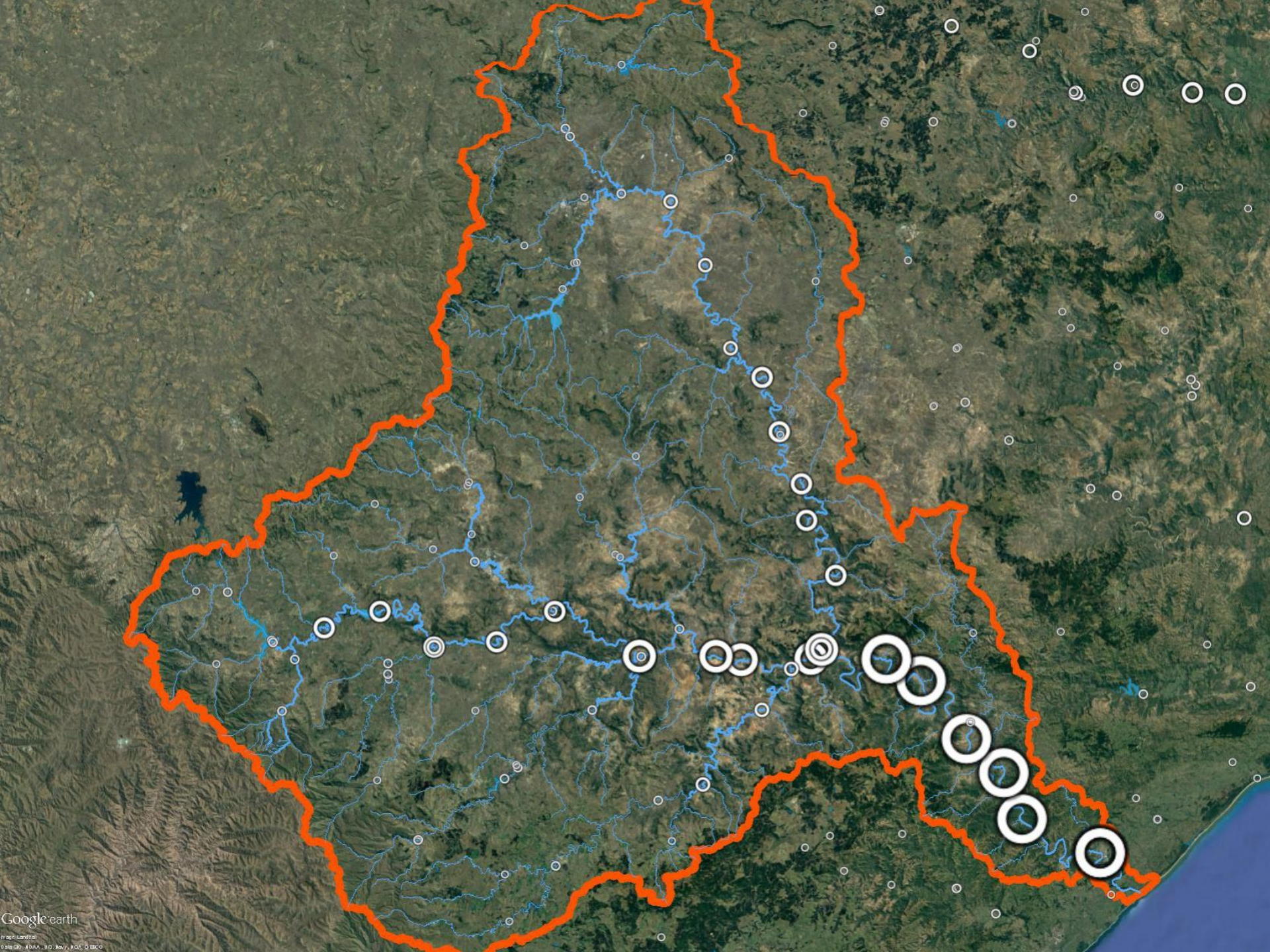
Hydrological Criteria:
Natural Unit Runoff per Quaternary

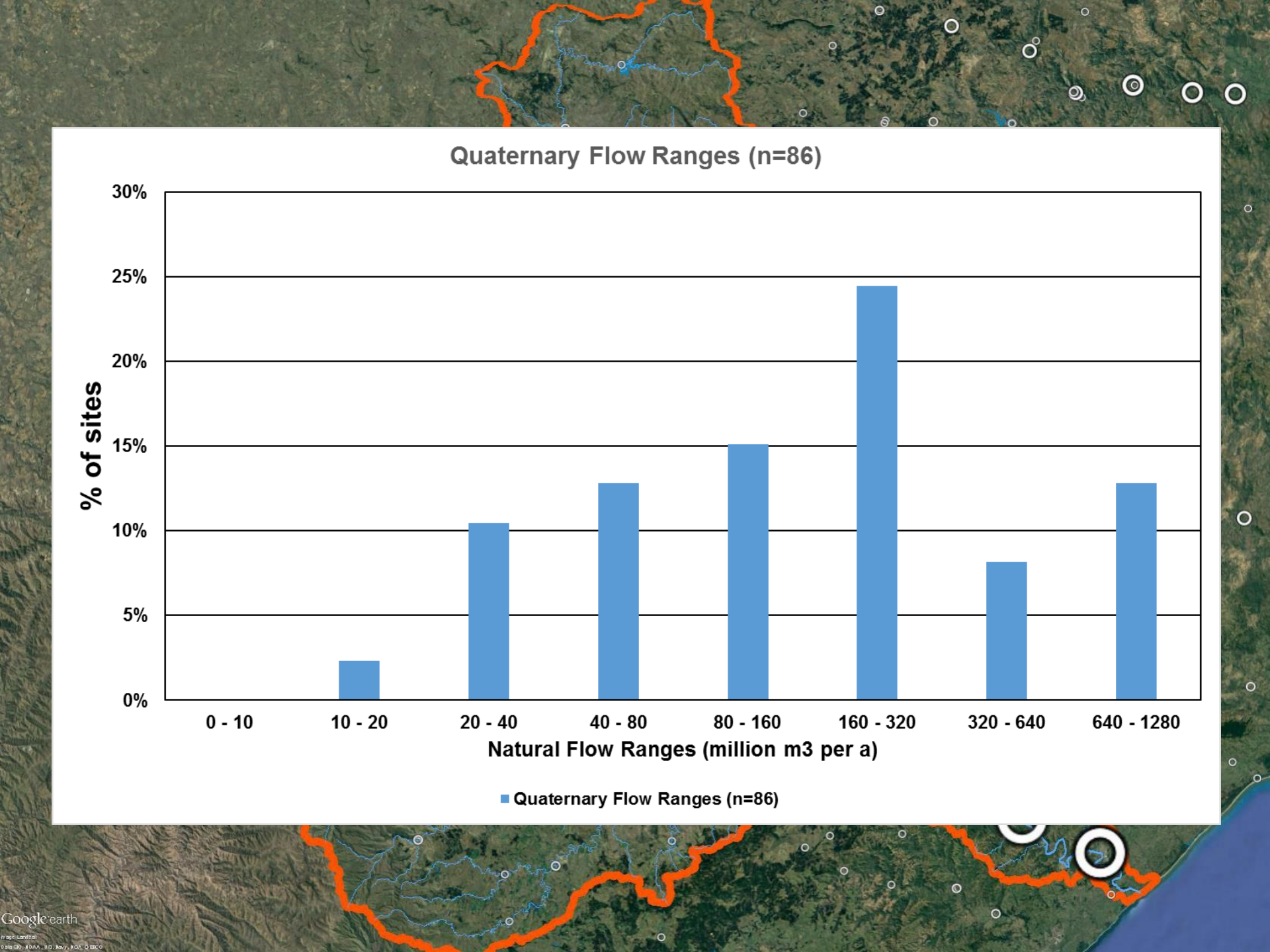
- Need to measure areas of **high runoff** (“Water Towers”)
- Used **Natural MAR** for each quaternary in terms of **unit runoff**
- Plotted in following categories (mm/a):
  - 0 – 10
  - 10 – 20
  - 20 – 50
  - 50 - 100
  - 100 – 200
  - 200 – 500
  - 500 -1000
  - >1000

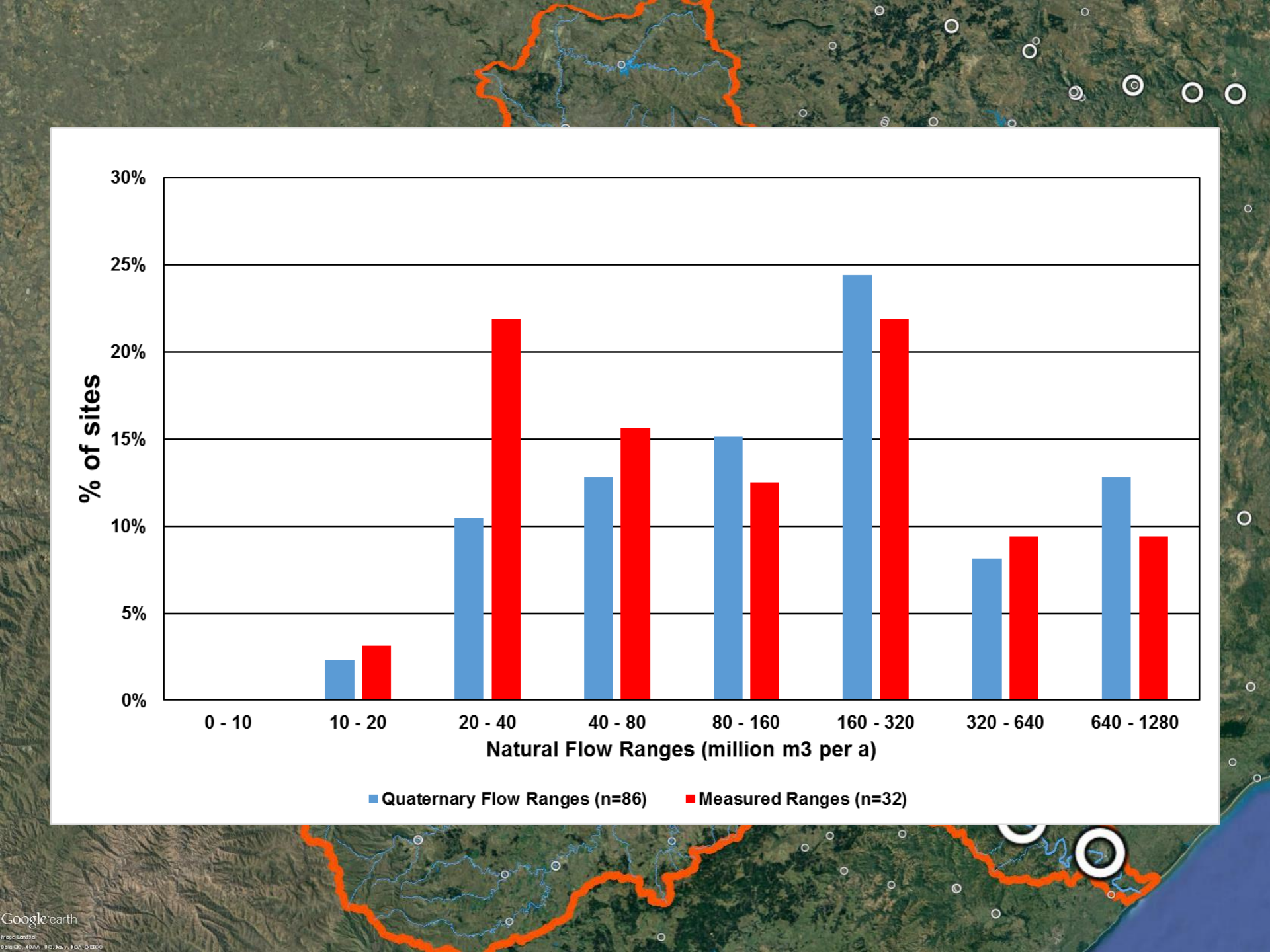

Google earth
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Hydrological Criteria: Base Distributions

- Generated two datasets:
  - Total (cumulative) natural MAR at the outlet of each quaternary.
  - Total natural flows for each current monitoring site (rivers and dams – ignore W-Components) – Cheat!
- Generated histograms per primary river catchment or group of rivers (coastal) of:
  - % of total flows for
  - set ranges of flows
- Dependant on shape of catchment boundaries and distribution of rainfall


Google earth


Quaternary Flow Ranges (n=86)
30%
25%
20%
15%
10%
5%
0%
% of sites
0 - 10
10 - 20
20 - 40
40 - 80
80 - 160
160 - 320
320 - 640
640 - 1280
Natural Flow Ranges (million m3 per a)
Quaternary Flow Ranges (n=86)


30%
25%
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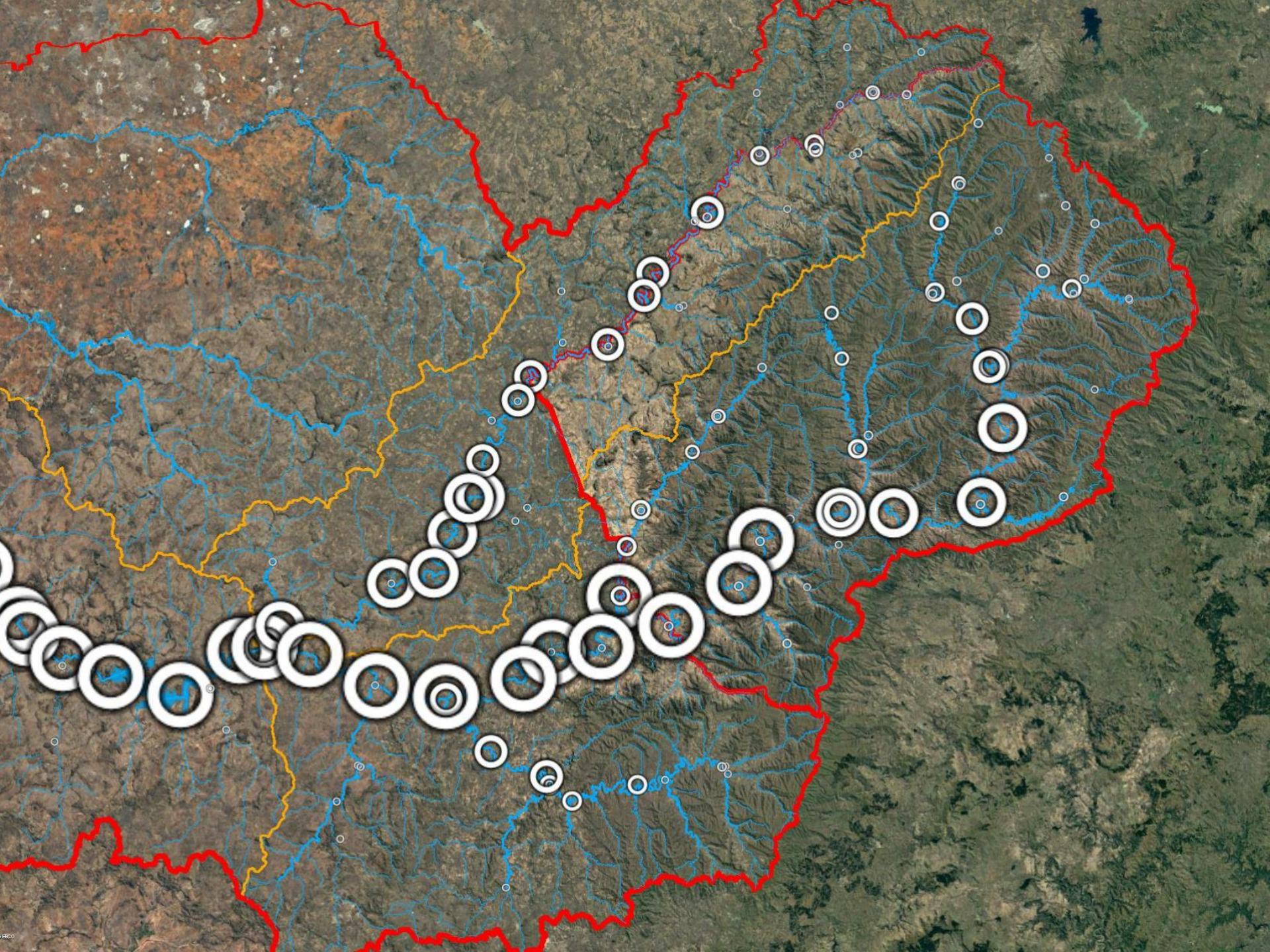
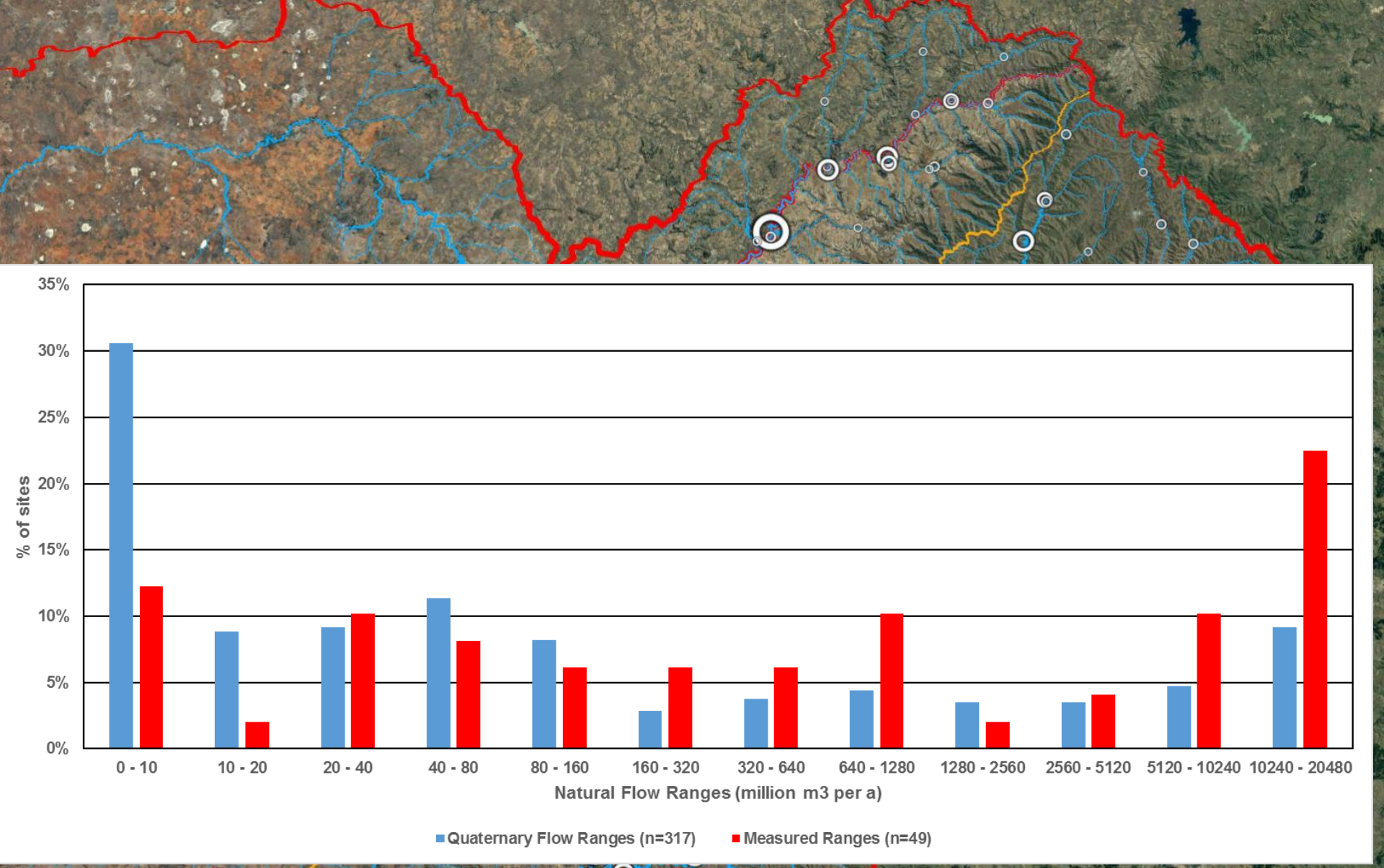
15%
10%
5%
0%
% of sites
0 - 10
10 - 20
20 - 40
40 - 80
80 - 160
160 - 320
320 - 640
640 - 1280
Natural Flow Ranges (million m3 per a)
Quaternary Flow Ranges (n=86)
Measured Ranges (n=32)
Google earth




35%
30%
25%
20%
15%
10%
5%
0%
% of sites
0 - 10
10 - 20
20 - 40
40 - 80
80 - 160
160 - 320
320 - 640
640 - 1280
1280 - 2560
2560 - 5120
5120 - 10240
10240 - 20480
Natural Flow Ranges (million m3 per a)
Quaternary Flow Ranges (n=317)
Measured Ranges (n=49)

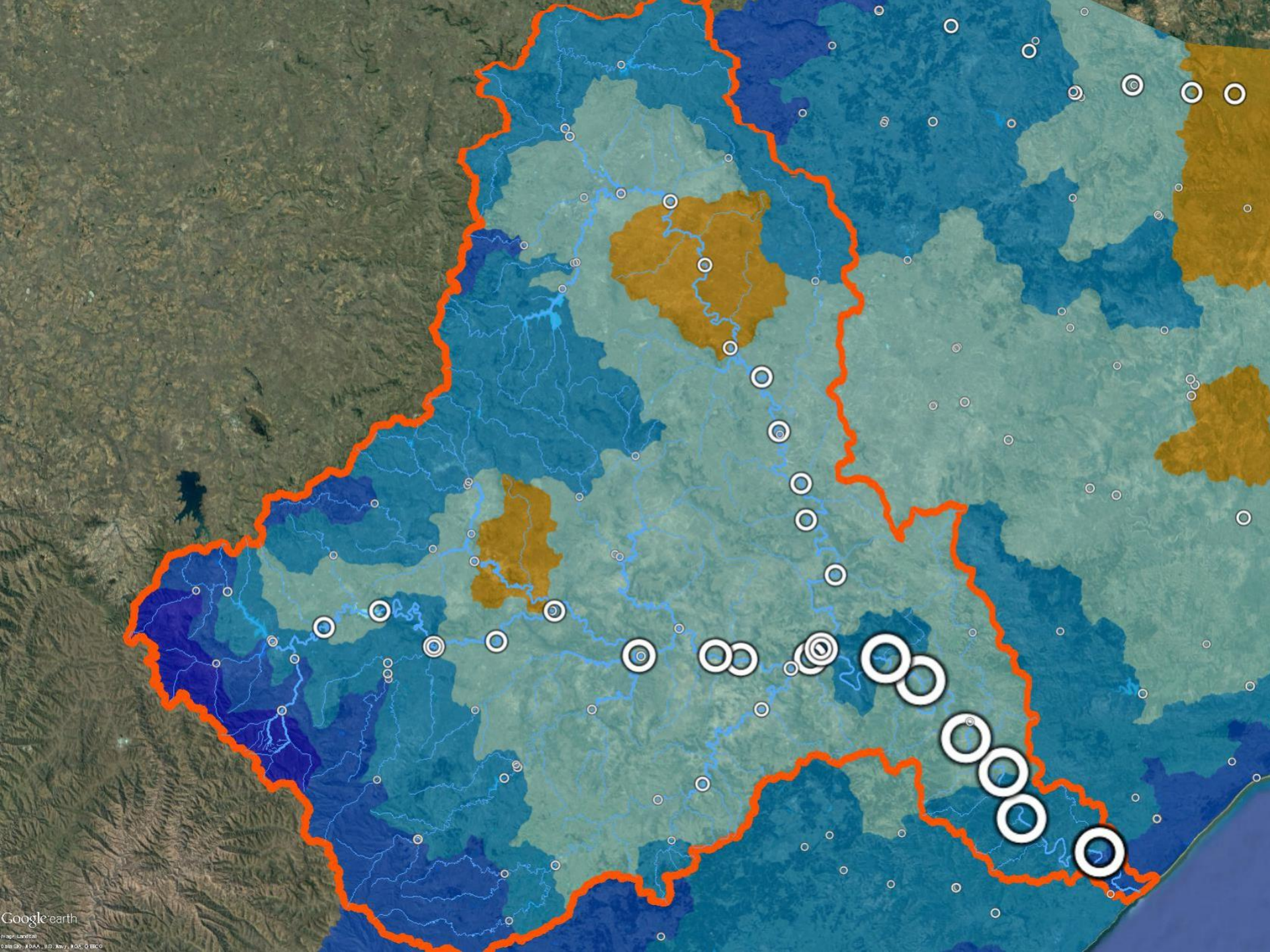

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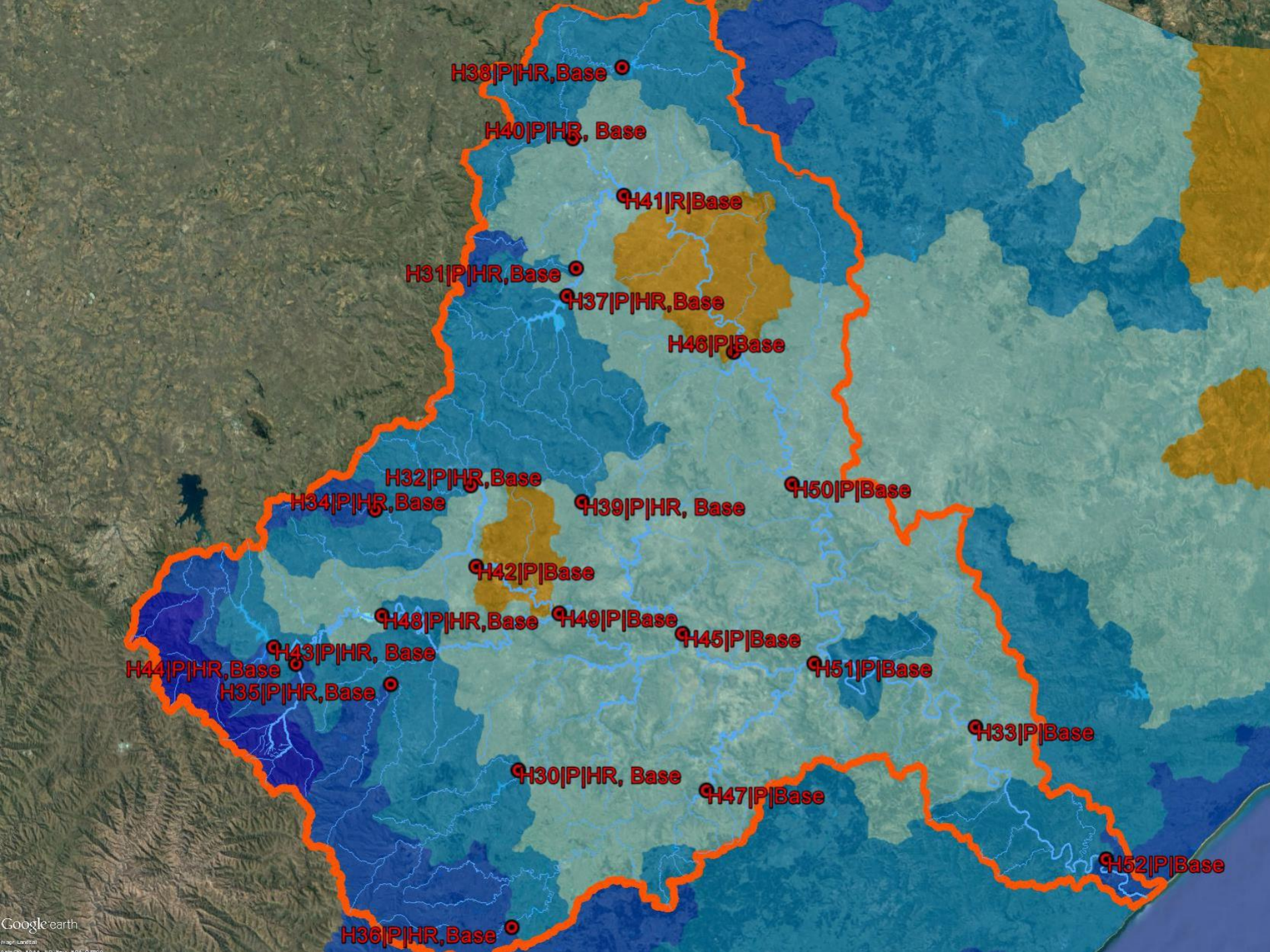
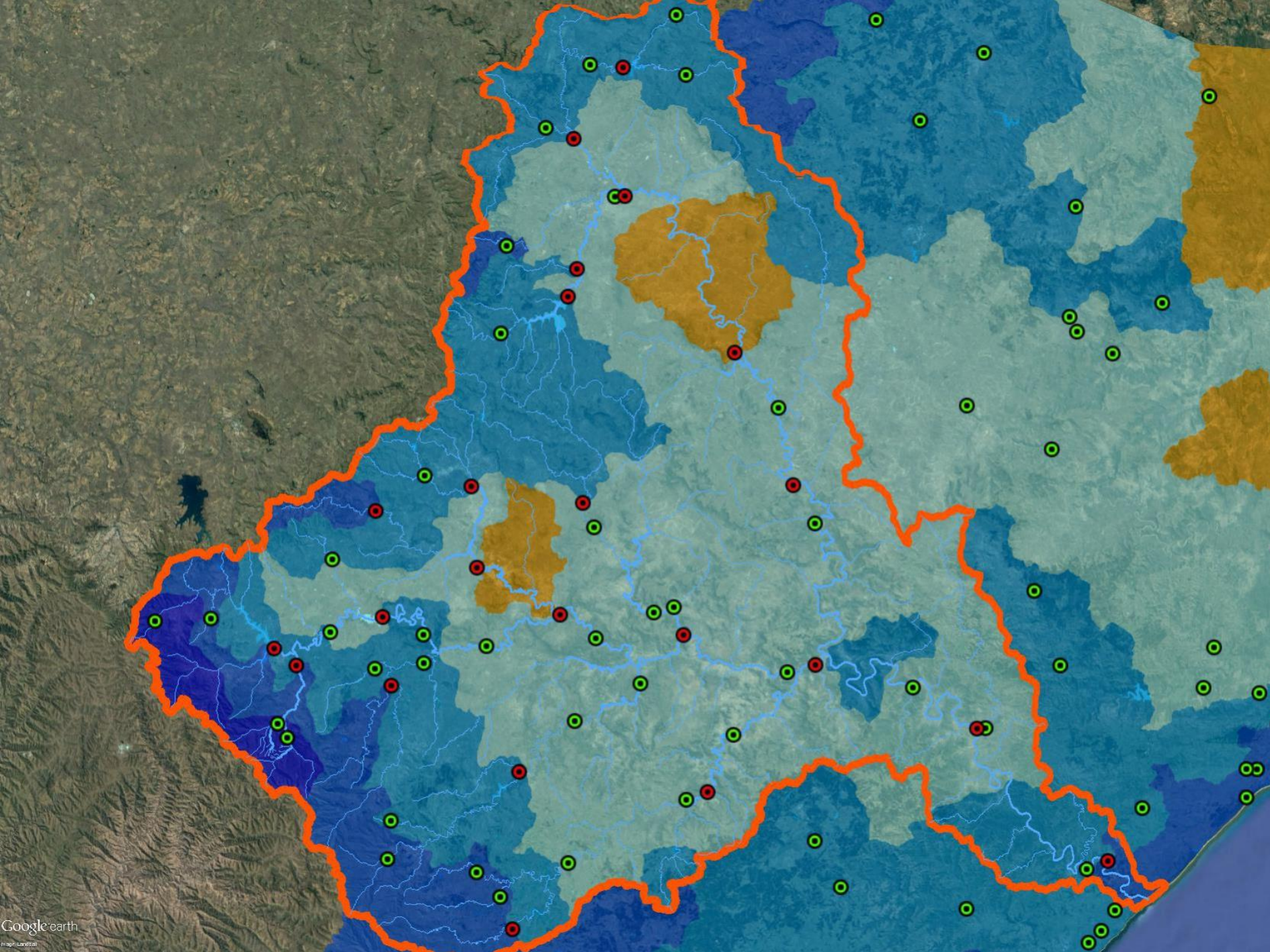
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO


H38|P|HR,Base
H40|P|HR, Base
H41|R|Base
H31|P|HR,Base
H37|P|HR,Base
H46|P|Base
H32|P|HR,Base
H34|P|HR,Base
H39|P|HR, Base
H50|P|Base
H42|P|Base
H48|P|HR,Base
H49|P|Base
H45|P|Base
H43|P|HR, Base
H44|P|HR,Base
H35|P|HR,Base
H51|P|Base
H33|P|Base
H30|P|HR, Base
H47|P|Base
H52|P|Base
H36|P|HR,Base
Google earth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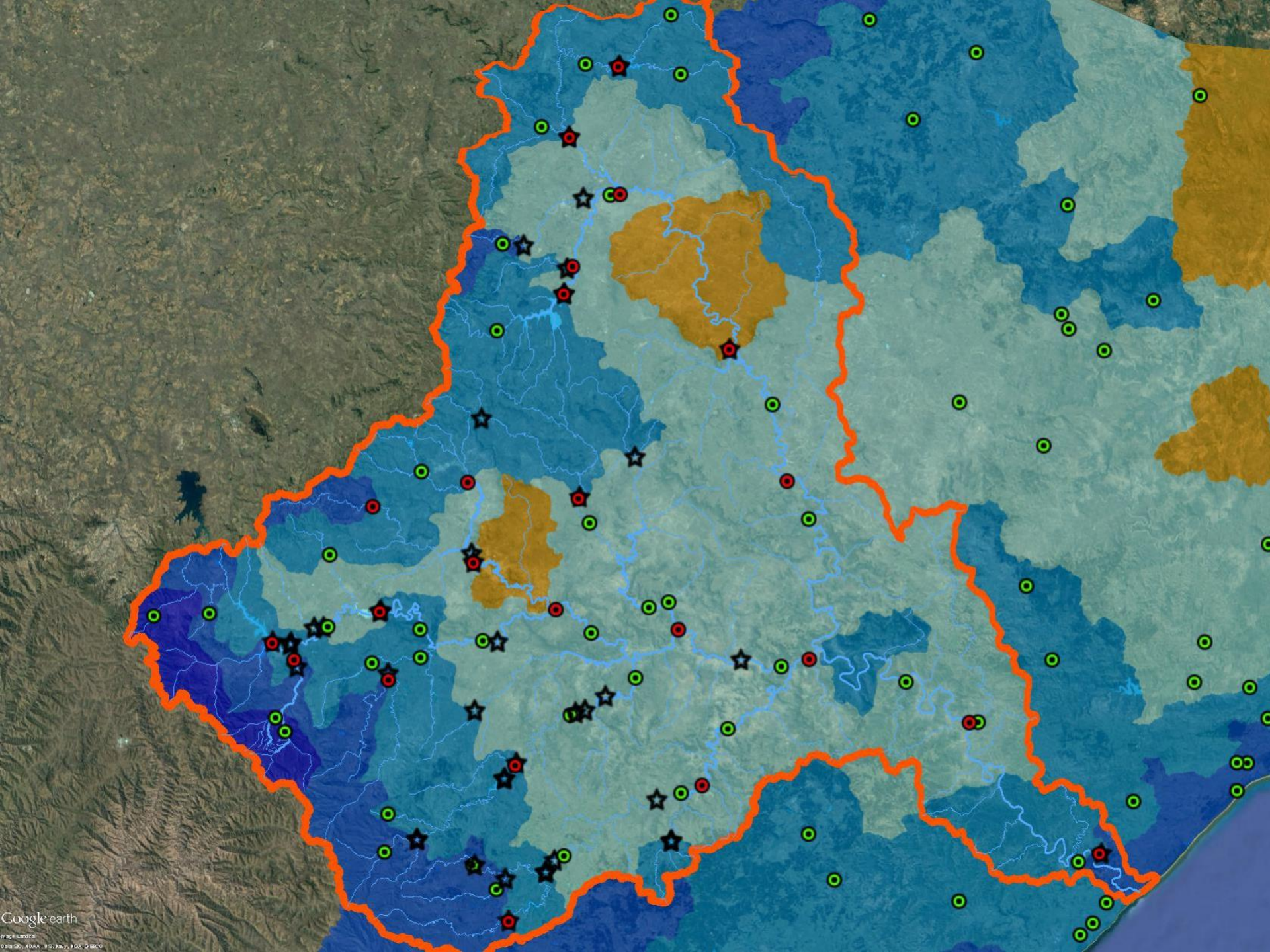
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Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Conclusions

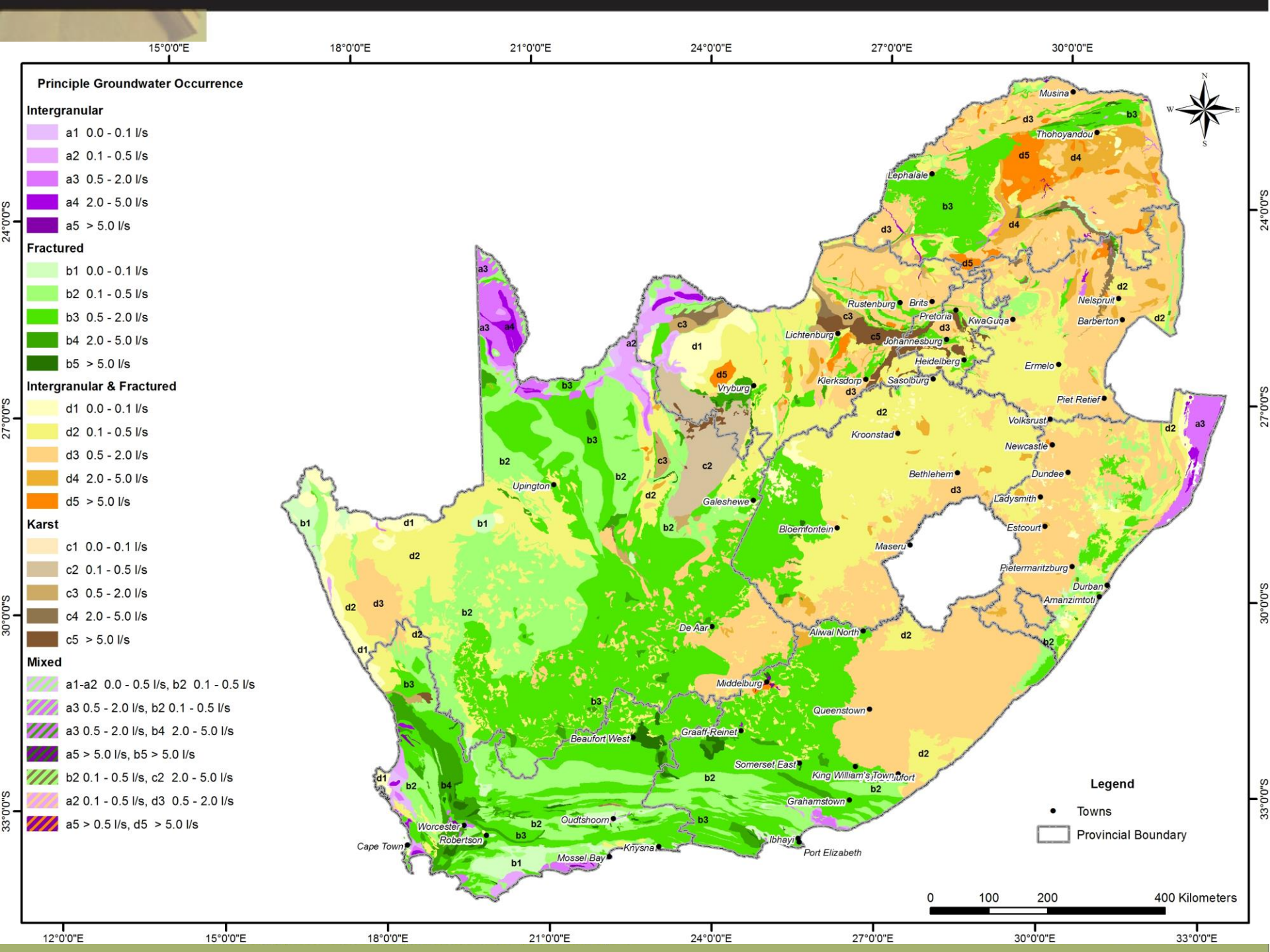
- All monitoring network reviews, redesigns and optimisation should **start with the objectives** of the network.
- From hydrological and geo-hydrological perspectives:
  - Expected natural conditions could support decision support on spatial distributions of network
  - High yielding areas should be monitored as priority
  - For surface water the flow characteristics of a range of representative flows should be covered
  - For groundwater baseline stations is key with trend monitoring for anthropogenic effects.

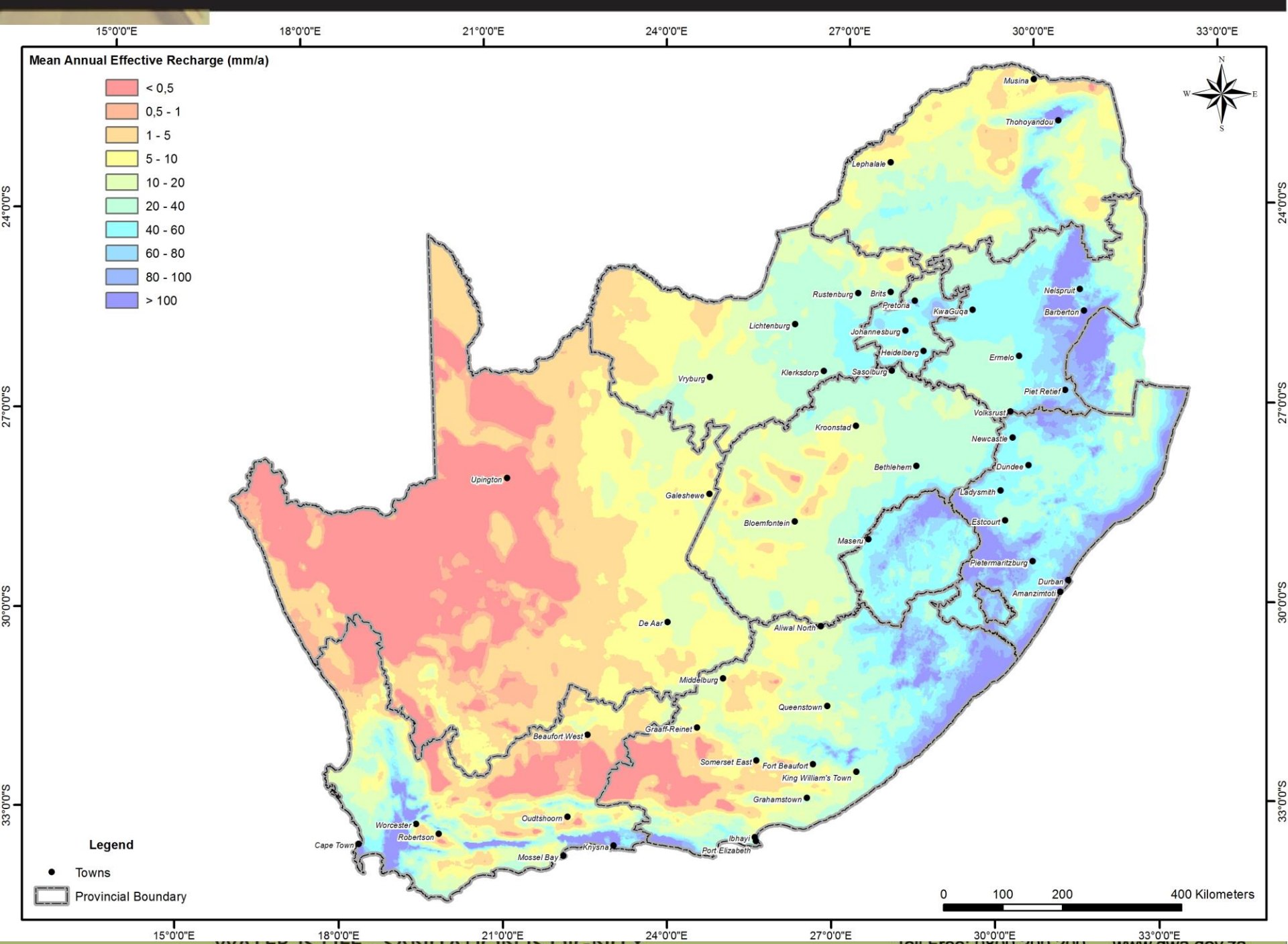
Geo-hydrological Criteria

- Same review process followed as for surface water
- Status Quo of groundwater level network established in September 2014.
- Developed theoretical network in terms of baseline monitoring sites using GRA2 national datasets.
- On WMA workshops:
  - Identified trend monitoring sites
  - Assigned existing sites as baseline and trend sites

Datasets

- Transboundary aquifers
- Aquifer yield classification
- Recharge
- Negative land cover
- Water quality maps
- Vulnerability
- Land cover
- AMD/Fracking/RBIG/IDZs
- RQO sites
- Bulk water Users


Principle Groundwater Occurrence
Intergranular
a1 0.0 - 0.1 l/s
a2 0.1 - 0.5 l/s
a3 0.5 - 2.0 l/s
a4 2.0 - 5.0 l/s
a5 > 5.0 l/s
Fractured
b1 0.0 - 0.1 l/s
b2 0.1 - 0.5 l/s
b3 0.5 - 2.0 l/s
b4 2.0 - 5.0 l/s
b5 > 5.0 l/s
Intergranular & Fractured
d1 0.0 - 0.1 l/s
d2 0.1 - 0.5 l/s
d3 0.5 - 2.0 l/s
d4 2.0 - 5.0 l/s
d5 > 5.0 l/s
Karst
c1 0.0 - 0.1 l/s
c2 0.1 - 0.5 l/s
c3 0.5 - 2.0 l/s
c4 2.0 - 5.0 l/s
c5 > 5.0 l/s
Mixed
a1-a2 0.0 - 0.5 l/s, b2 0.1 - 0.5 l/s
a3 0.5 - 2.0 l/s, b2 0.1 - 0.5 l/s
a3 0.5 - 2.0 l/s, b4 2.0 - 5.0 l/s
a5 > 5.0 l/s, b5 > 5.0 l/s
b2 0.1 - 0.5 l/s, c2 2.0 - 5.0 l/s
a2 0.1 - 0.5 l/s, d3 0.5 - 2.0 l/s
a5 > 0.5 l/s, d5 > 5.0 l/s
15°0'0"E
18°0'0"E
21°0'0"E
24°0'0"E
27°0'0"E
30°0'0"E
12°0'0"E
33°0'0"E
24°0'0"S
27°0'0"S
30°0'0"S
33°0'0"S
N
S
W
E
Musina
Thohoyandou
Lephalale
Nelspruit
Barberton
Rustenburg
Brits
Pretoria
KwaGuqa
Lichtenburg
Johannesburg
Heidelberg
Ermelo
Vryburg
Klerksdorp
Sasolburg
Piet Retief
Volksrust
Kroonstad
Newcastle
Bethlehem
Dundee
Ladysmith
Upington
Galeshewe
Bloemfontein
Estcourt
Maseru
Pietermaritzburg
Durban
Amanzimtoti
De Aar
Aliwal North
Middelburg
Queenstown
Graaff-Reinet
Beaufort West
Somerset East
King William's Town
Grahamstown
Oudtshoorn
Worcester
Robertson
Cape Town
Knysna
Mossel Bay
Ibhayi
Port Elizabeth
Legend
Towns
Provincial Boundary
0
100
200
400 Kilometers


Mean Annual Effective Recharge (mm/a)
< 0,5
0,5 - 1
1 - 5
5 - 10
10 - 20
20 - 40
40 - 60
60 - 80
80 - 100
> 100
15°0'0"E
18°0'0"E
21°0'0"E
24°0'0"E
27°0'0"E
30°0'0"E
33°0'0"E
24°0'0"S
27°0'0"S
30°0'0"S
33°0'0"S
N
S
E
W
Musina
Thohoyandou
Lephalale
Rustenburg
Brits
Pretoria
KwaGuqa
Nelspruit
Barberton
Lichtenburg
Johannesburg
Heidelberg
Ermelo
Klerksdorp
Sasolburg
Vryburg
Piet Retief
Volksrust
Kroonstad
Newcastle
Bethlehem
Dundee
Upington
Galeshewe
Ladysmith
Bloemfontein
Estcourt
Maseru
Pietermaritzburg
Durban
Amanzimtoti
De Aar
Aliwal North
Middelburg
Queenstown
Graaff-Reinet
Beaufort West
Somerset East
Fort Beaufort
King William's Town
Grahamstown
Oudtshoorn
Worcester
Robertson
Cape Town
Knysna
Mossel Bay
Ibhayi
Port Elizabeth
Legend
Towns
Provincial Boundary
0
100
200
400 Kilometers

ngwmn_framework_report_july2013.pdf (SECURED) - Adobe Acrobat

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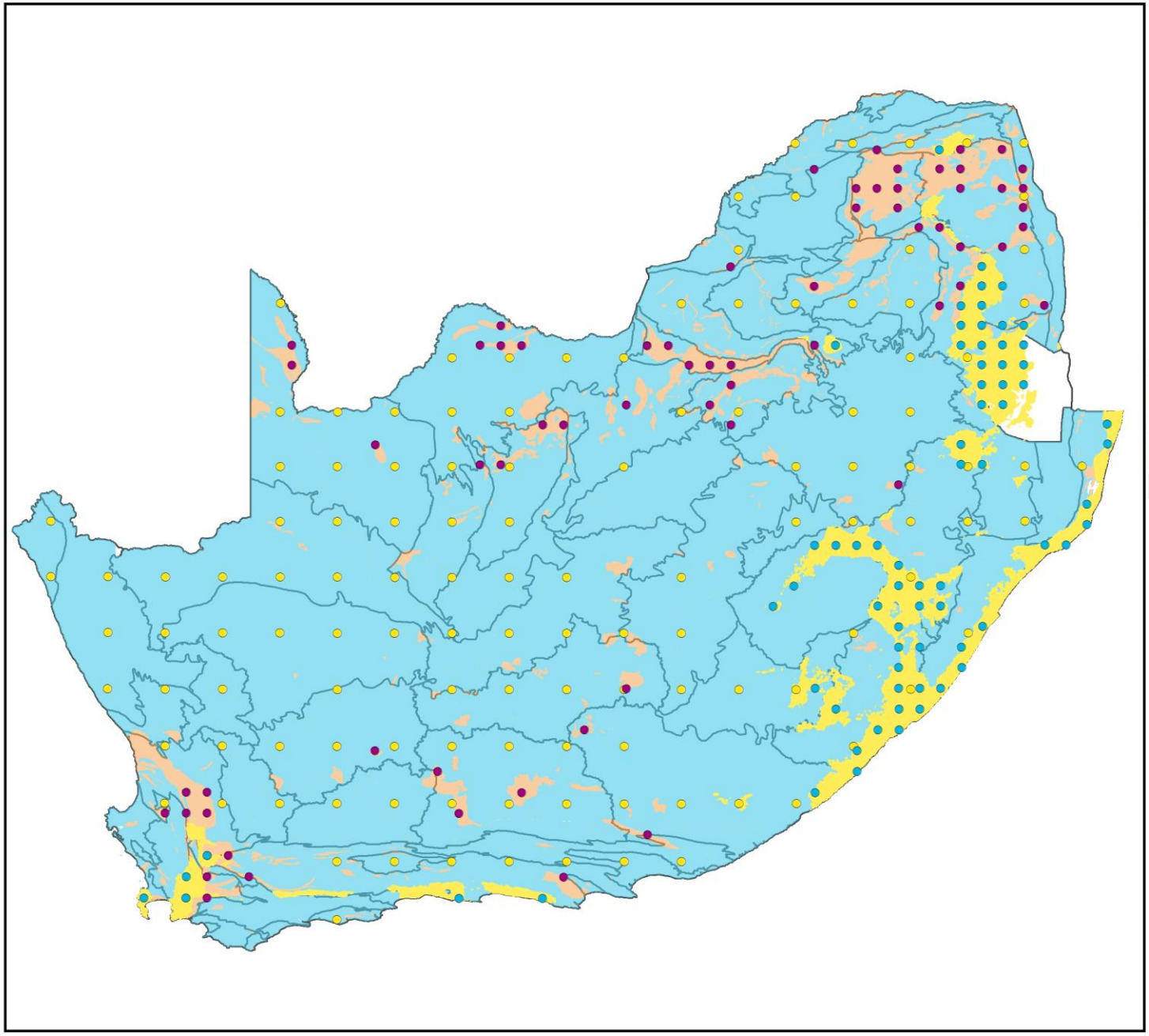
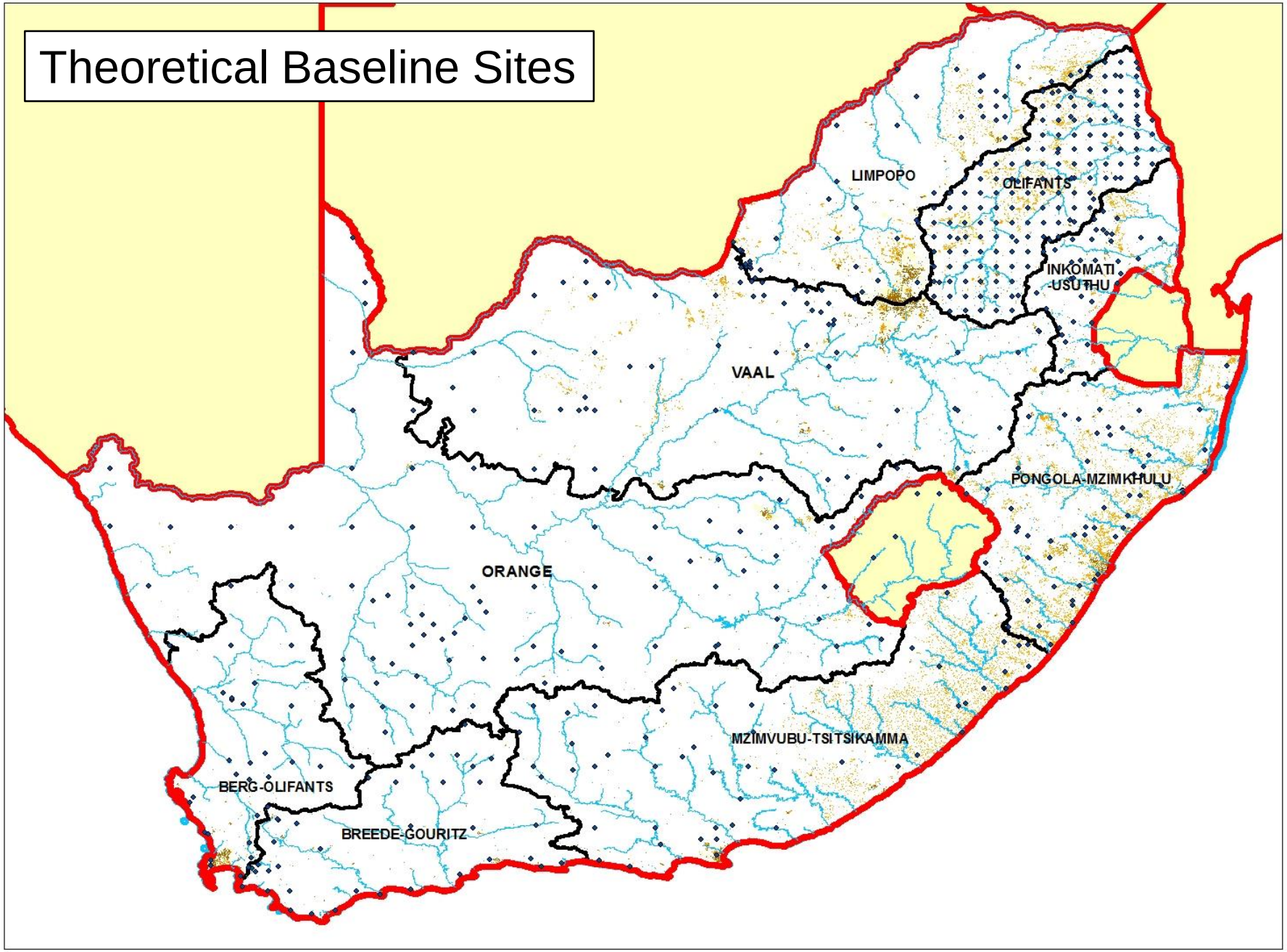
A National Framework for Ground-Water Monitoring in the United States

Prepared by The Subcommittee on Ground Water of The Advisory Committee on Water Information

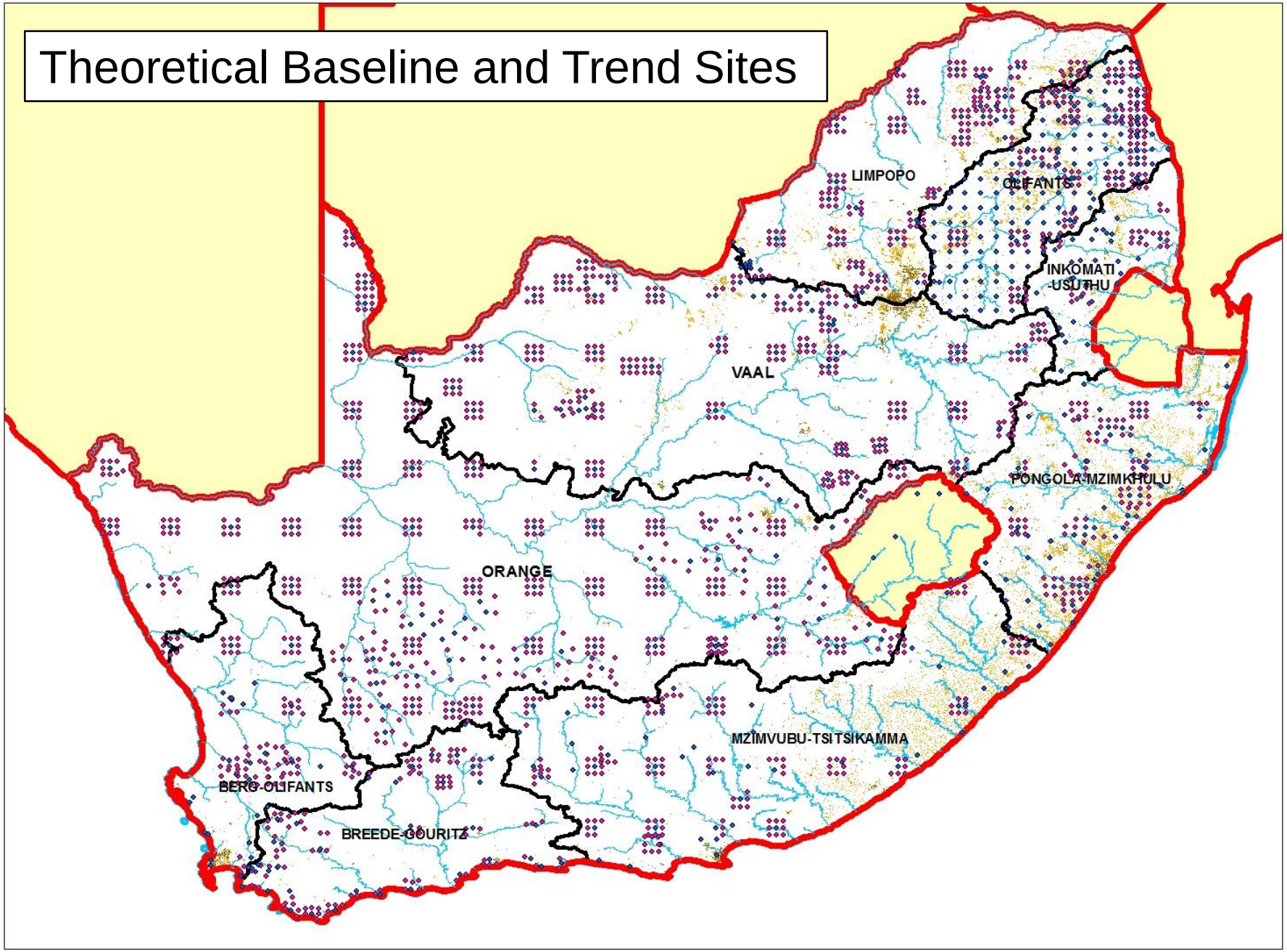
Approved by The Advisory Committee on Water Information


Legend
Base Stations (All Priority 1.1):
Recharge >=80 mm/a - 1000 km²
High Yield Aquifers and Negative Landcover – 1000km²
Low Yield Aquifers and Negative Landcover – 7500km²
Datasets:
Mean Annual Recharge >=80 mm/a
High Yield Aquifer
Low Yield Aquifer
Vegter's Groundwater Regions

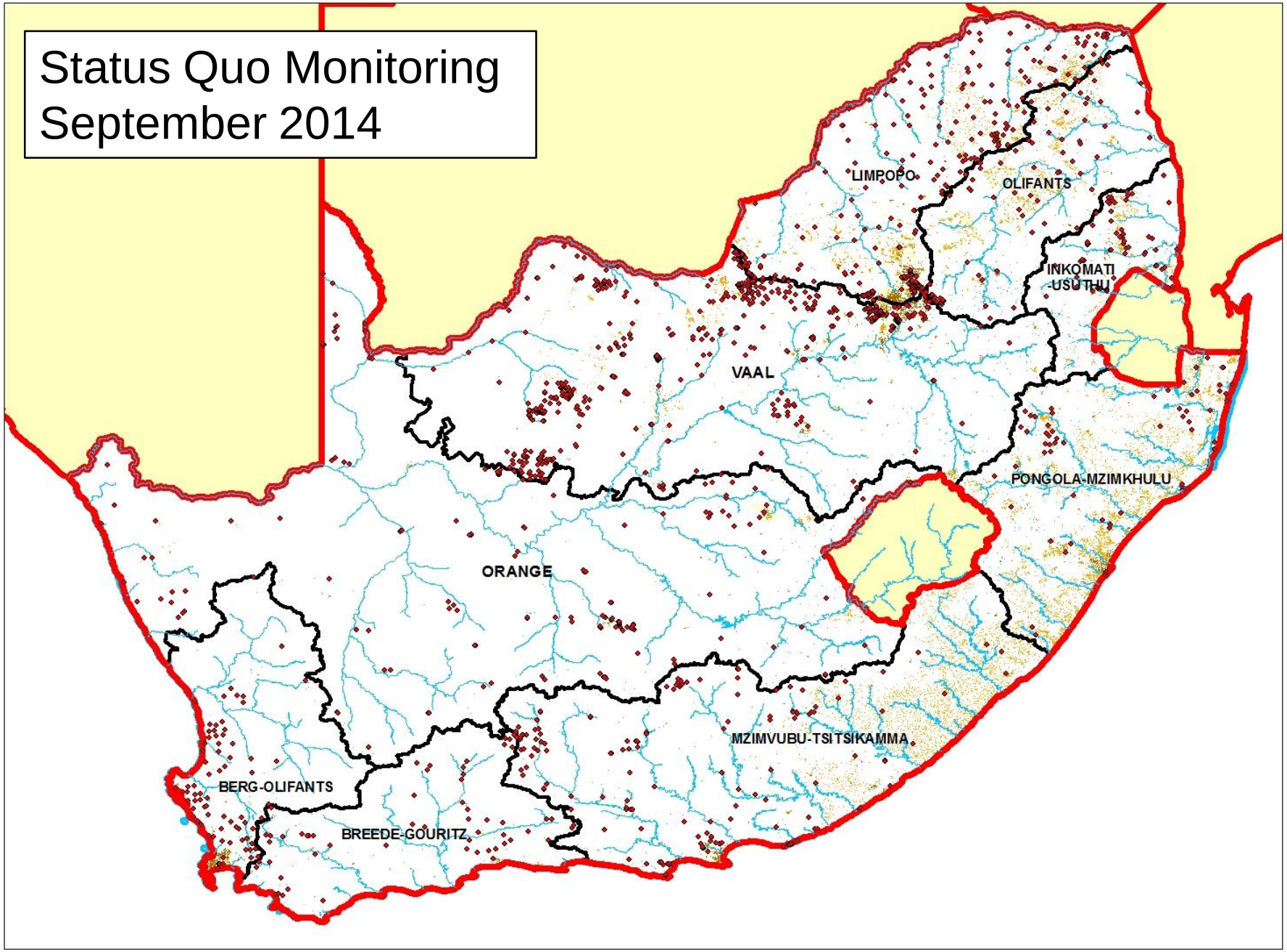
Theoretical Baseline Sites



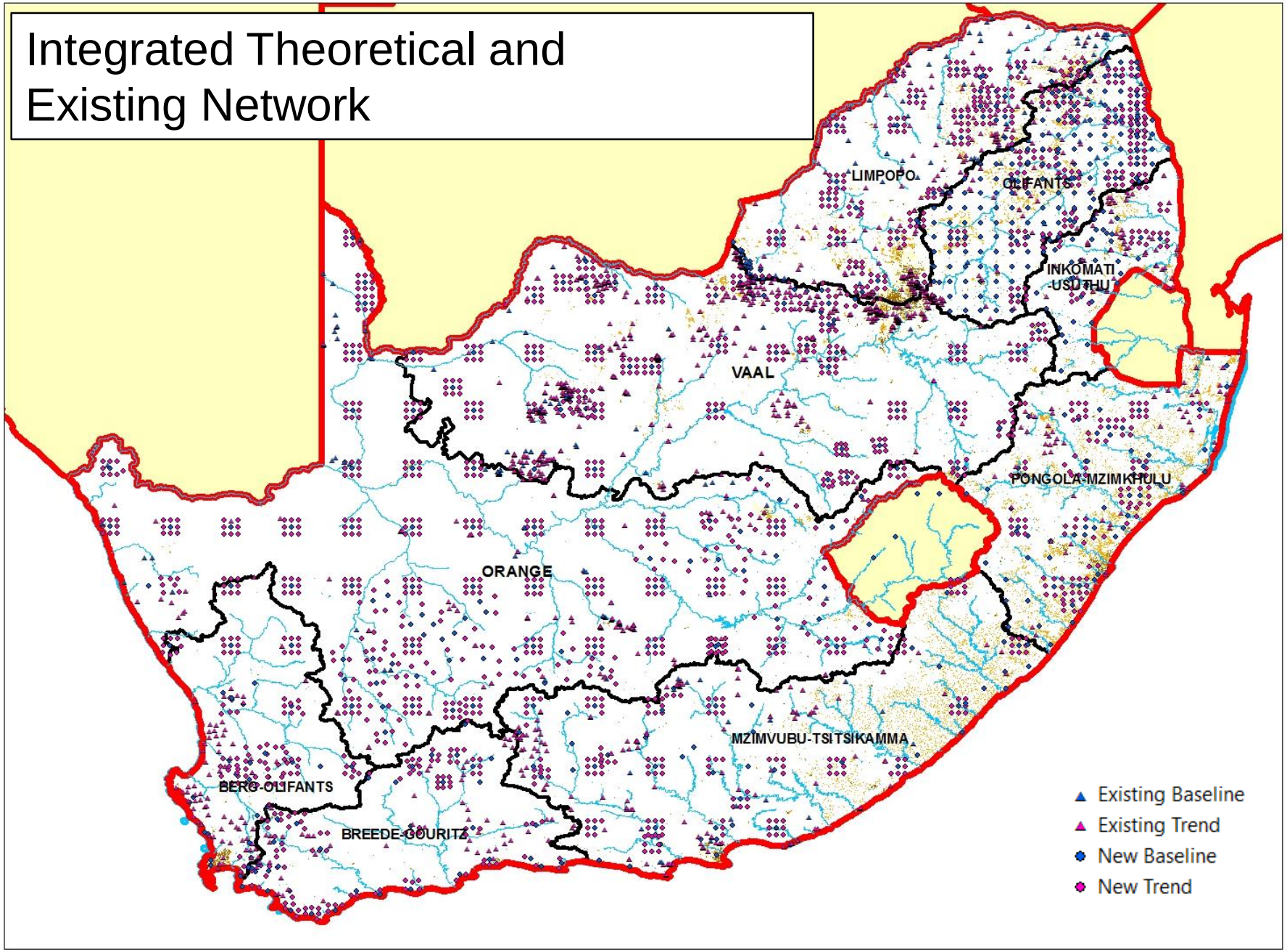
Theoretical Baseline and Trend Sites



Status Quo Monitoring
September 2014



Integrated Theoretical and Existing Network



Reports and data

https://www.dwa.gov.za/Projects/NWRM/default.aspx

Or

DWS Website|Projects and Programmes|

Review, Evaluation and Optimisation of the National Water Resources Monitoring (NWRM) Network Project