Earth Stewardship Science Research Institute

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Low-level river crossings and erosion repair of the access road for general ease of access and secure transportation of the Lunar Laser Ranger and radio telescope equipment to the Matjiesfontein Space Geodesy Observatory

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Access to the Matjiesfontein Space Geodesy Observatory (MGO) is currently being compromised as the road is in a poor condition and intercepts five drainage channels along the way. It is important that safe and reliable access be granted to the site as large, sensitive and expensive instruments need to be transported to site and for hauling material and machinery during construction. Once the observatory is functional, staff members and guest researchers will need to be able to drive to the site per normal light vehicle.

Low-level river crossings

Problem

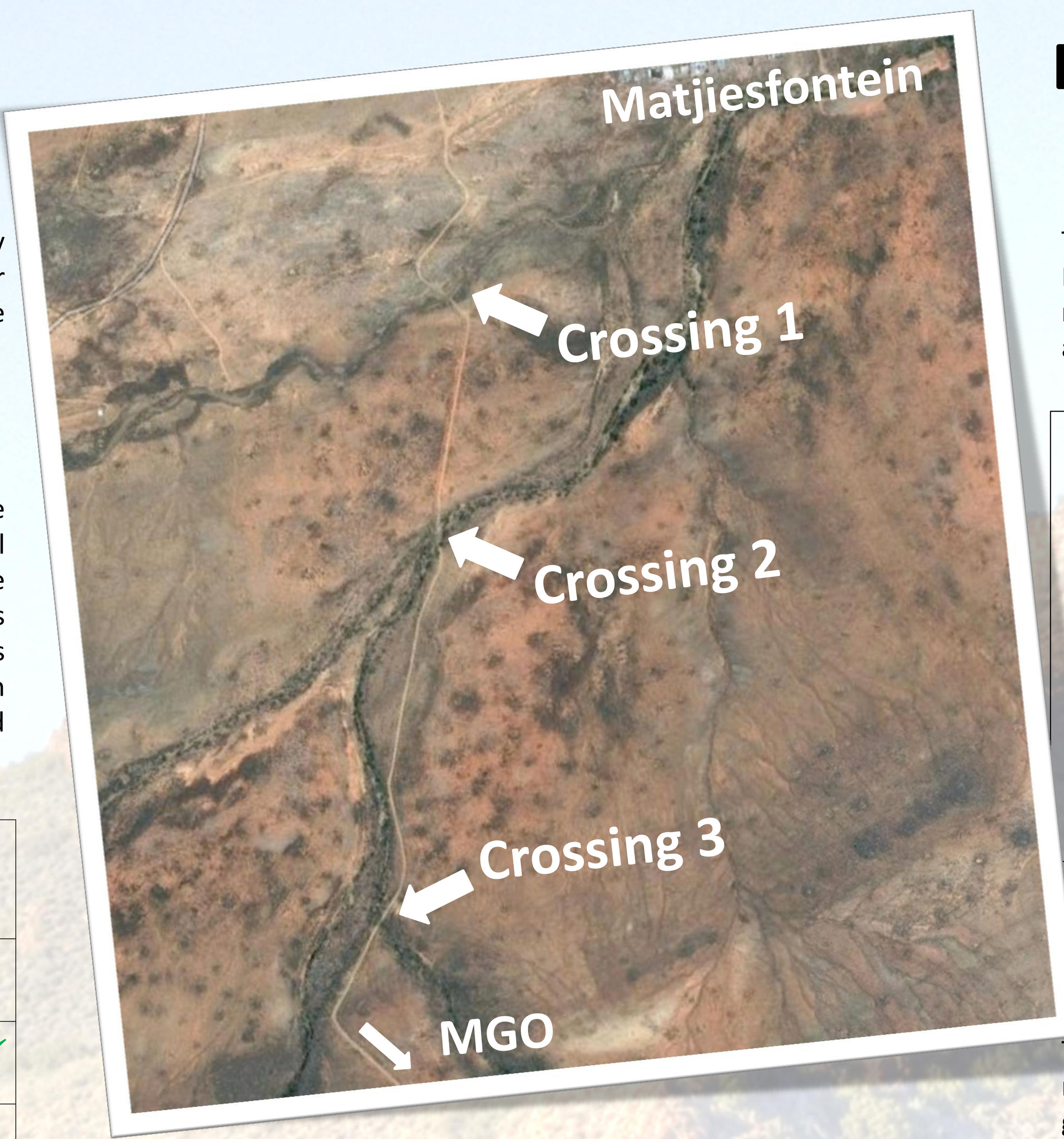
There are currently no structures to allow for safe and reliable passage at any of the crossings and therefore low-level river crossings have to be designed for the first three as seen on the picture to the right. The crossings should ensure access to the MGO at all times, including the rainy season.

Method

The catchment areas that are contributing flow to each crossing were calculated and the mean annual precipitation for Matjiesfontein acquired. All catchment areas were smaller than 15km^2, allowing the rational method to be used in order to estimate the peak flow at each crossing. A design factor is then applied to the peak flow to obtain the design flow. The flow capacity was calculated for at-grade fords and should be greater than the respective design flow. Crossing 2 is larger than the other and necessitates the use of a vented ford, which has a greater capacity as seen in the table below.

River crossing	Peak flow (m^3/s)	Design level factor	Design flow (m^3/s)	At-grade ford capacity (m^3/s)	Vented ford capacity (m^3/s)
1	4.62	0.25	1.16	1.71 ✓	-
2	18.53	0.25	4.63	1.31 ✗	12.72 ✓
3	4.16	0.25	1.04	1.18 ✓	-

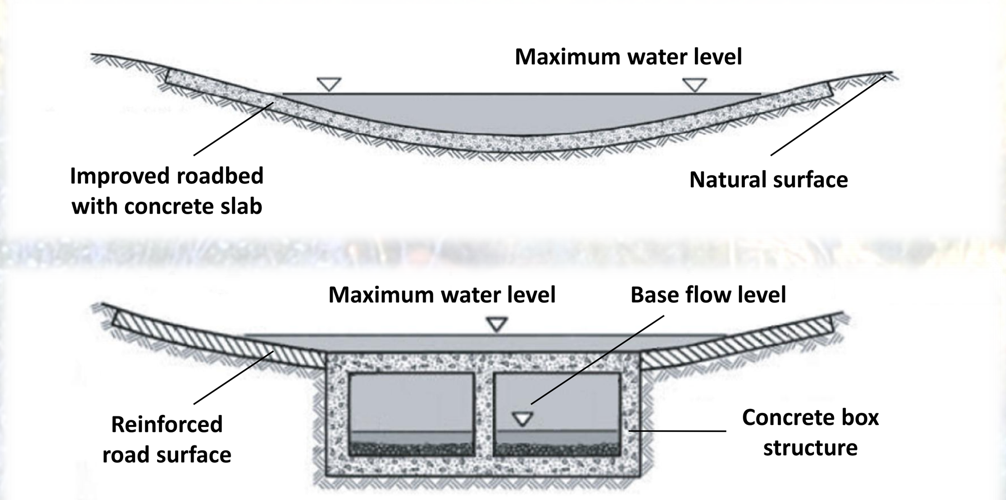
Calculated design flow and flow capacity for each river crossing



Aerial view of the three river crossings within section 1 of the access road

Recommendations

From the hydraulic calculations, at-grade fords are recommended for crossing 1 and crossing 3, and a box vented ford for crossing 2. Construction of the crossings should be carried out during the dry season when the water level is low or preferably when it is dry. Due to the concrete having to cure for at least seven days it is recommended that the construction team should start with crossing 3 and work back towards Matjiesfontein. This will enable the construction team to start working on crossing 2 without having to wait for the concrete slab of the first crossing to cure. The same applies for crossing 1.



At-grade (top) and box vented (bottom) fords

Flow over gabion

DCP test

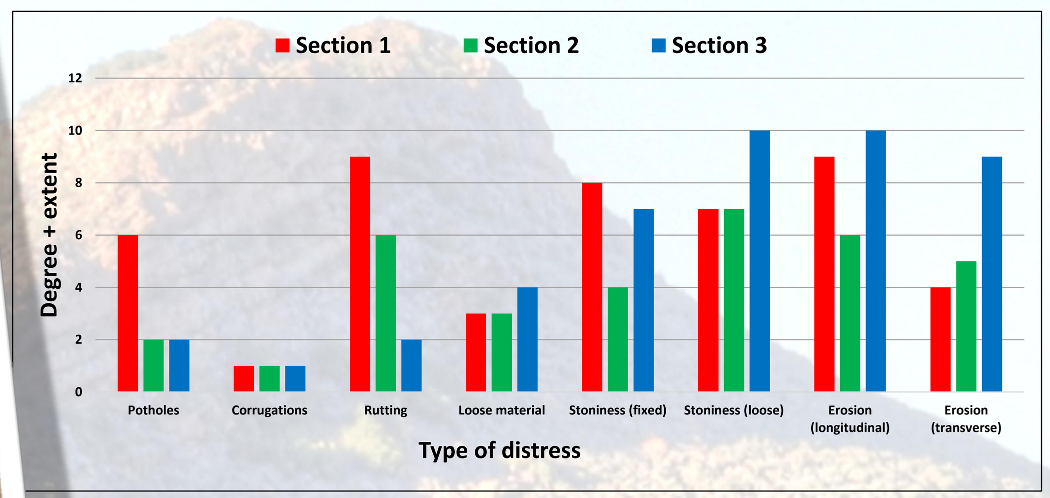
River crossing

Erosion of the road

Erosion repair of the access road

Problem

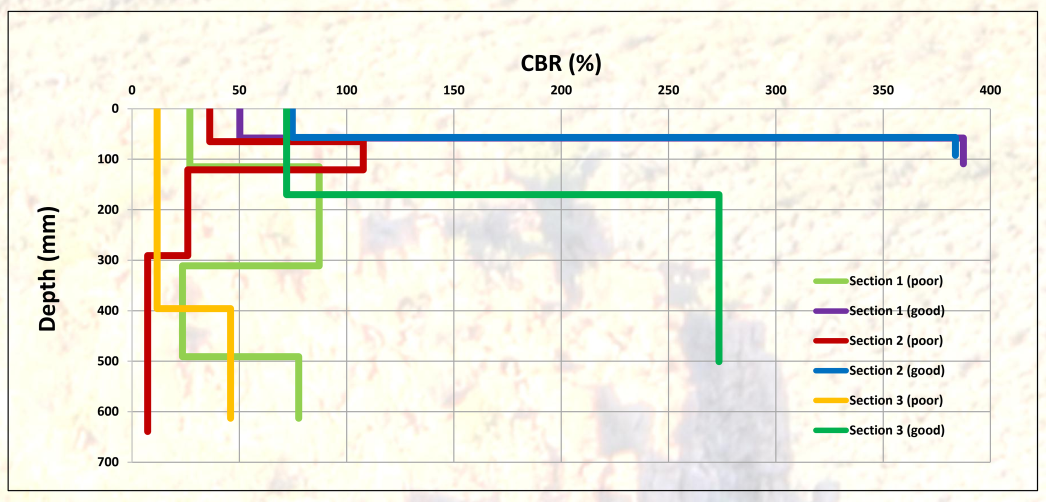
There is currently a basic existing dirt road which connects the town to the MGO, but its condition is not acceptable. Due to weathering and erosion, the road surface have degraded at a number of locations and renders difficulty of access to vehicles without any off-road capabilities.



Visual assessment for each road section

Method

The access road was divided into three sections. A visual assessment of the road was done to establish the major issues within each section. From the graph above it is evident that loose stones and longitudinal erosion are general problems, as well as excessive rutting in section 1 and transverse erosion in section 3. A total of 56 Dynamic Cone Penetrometer (DCP) tests were carried out in order to estimate the in-situ strength of the road material. After analysing the results, the California Bearing Ratio (CBR) was calculated for each test. The graph below shows the best and worst results for each of the three road sections.

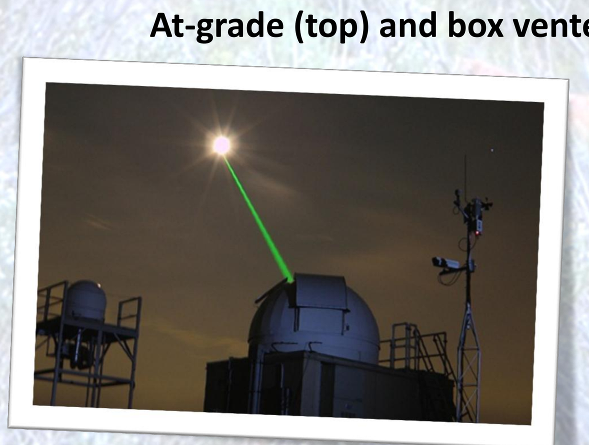


CBR results showing a poor and good result for each section

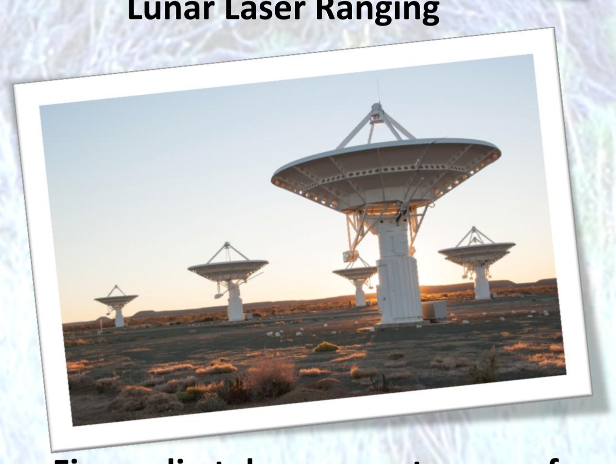
Recommendations

The material comprising the access road is overall very hard with bedrock often encountered near the surface. It is recommended however that the road surface be filled up and compacted as water is currently unable to escape the road and causes eroded material to wash away. Furthermore, side drainage should receive special attention.

The MGO Radio Telescope



Lunar Laser Ranging



Five radio telescope antennas of KAT-7 near Carnarvon

The large instruments that need to be transported to site are the Lunar Laser Ranger and radio telescope equipment, examples of which can be seen by the pictures to the left. As the MGO is to be an extension of the Hartebeesthoek Radio Astronomy Observatory (HartRAO), it is only fitting that the observatory be equipped with its own radio telescope, which can be used to conduct geodetic very long baseline interferometry experiments among other. This technique allows scientists to determine the distances (baselines) between individual radio telescope antennas continuously, enabling continental drift to be measured. The telescope at HartRAO, shown on the right, moves at a rate of 2.5cm per year in the North-East direction. Currently, two 34m diameter NASA radio telescope antennas are expected to be installed at the MGO. Research are thus aimed at the successful installation of the structures from a geotechnical perspective.

Supergroup	Group	Formation	Dominant rock
Karoo	Dwyka	Dwyka	Tillite
Cape	Witteberg	Waaipoort	Grey shale
Cape	Witteberg	Floriskraal	Shale and quartzitic sandstone
Cape	Witteberg	Kweekvlei	Shale
Cape	Witteberg	Witpoort	Sandstone

Geology at the MGO

Aerial view of the MGO

Radio telescope at HartRAO

The MGO site itself falls within the Witteberg Group of the Cape Supergroup. The structures will have to be placed on flat terrain, which will be somewhere in the valley where sub-vertical Floriskraal and Kweekvlei shales are prominent. The safe bearing capacity in SABS 0161 (1980) for shales is only 200 – 400MPa. Heaving might also pose a problem and settlement will be critical.

Proper foundations should thus be designed to ensure exceptional stability of the structures, as they need to point accurately at distant celestial objects and survive high wind speeds. They will also be at risk of being exposed to geohazards such as flooding, seismicity, landslides and rock fall. These geological and environmental events can cause catastrophic damage and require ample consideration.

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