Exploring Levee Systems of the DeGrey River: Geomorphological and Reservoir Potential

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Abstract

The ephemeral DeGrey River of northwestern Australia's Pilbara region presents unusual very high relief double levees of up to 5.8 m that are still poorly understood. This study aims to take advantage of excellent exposures of these double levees to assess their likely origin. Accessing and studying these features in a modern setting constitute a unique opportunity to better understand their geomorphology and evaluate their reservoir potential as an analogue for the subsurface.

We investigated these levees using shallow augering, percussion coring, digging of shallow pits, and ground-penetrating radar (GPR), calibrated using dGPS surveys. Remote sensing data, such as LIDAR and photogrammetric drone surveys, were also used to identify and visualize fluvial geomorphologic features, which were then ground truth by pedestrian surveys and general field observations. Core and auger samples were described according to grain texture using the USDA classification and a Munsell color atlas. to distinguish the similarities or differences from sediments by depth. Grain size was further assessed in sand and gravel using a Brunton Grain Size Card.

These levees were primarily developed by water during multiple large flooding events which exceeded their height limit, as opposed to the alternative hypothesis that these were large eolian features coincidental with levee positions at the channel margin. This is evidenced by the common layers of gravelly and poorly sorted coarse sand dispersed within the levee strata. Similarly, sedimentary structures of lower and upper flow regimes typical of water flood are observed for these strata. Locally, the outer part of the two levees was found to include an eolian cap, which provided additional height to the levee locally. These strata were fine-grained and well-sorted by contrast, typical of aeolian origins.

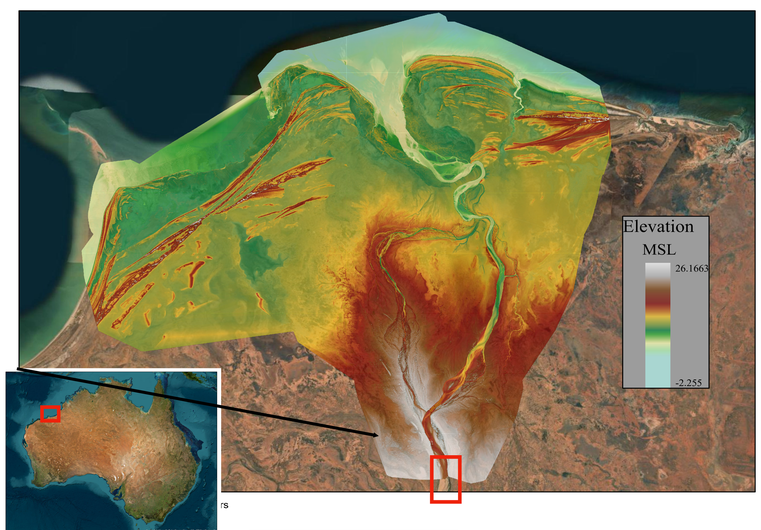
Cyclone-driven floods control the activation of the DeGrey River and associated

Background

The DeGrey River Delta in northwestern Australia is a perfect example of a multifarious coastal region morphed by the surrounding subtropical climate. The effects of the El Niño Southern Oscillation is what drive carbonate-terrigenous sediments, along with sea-level variability. Many of these factors are what contribute to the formation of geomorphological features such as: mangroves, tidal flats, spits, and levees. With all of these contributions from nature, it can be said that this specific delta is prone to a variety of storm surges, flooding, and cyclones.

- Delta supports diverse ecosystems, which provide natural protection against erosion.
- Large sand ridges extend past 60 km offshore from delta shore.
- The waters surrounding DeGrey River Delta are profoundly shallow, influencing sediment deposition and tidal patterns.

Study Area - DeGrey River, Western Australia



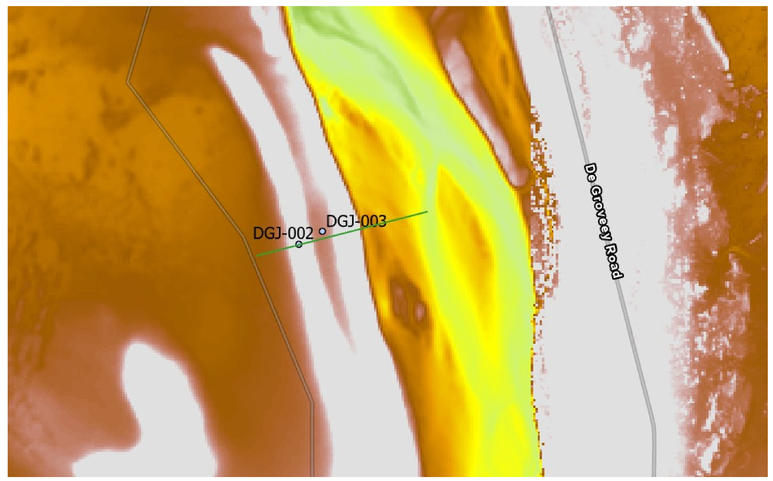
Main Question!

How do varying discharge events affect the sedimentation and subsequent levee

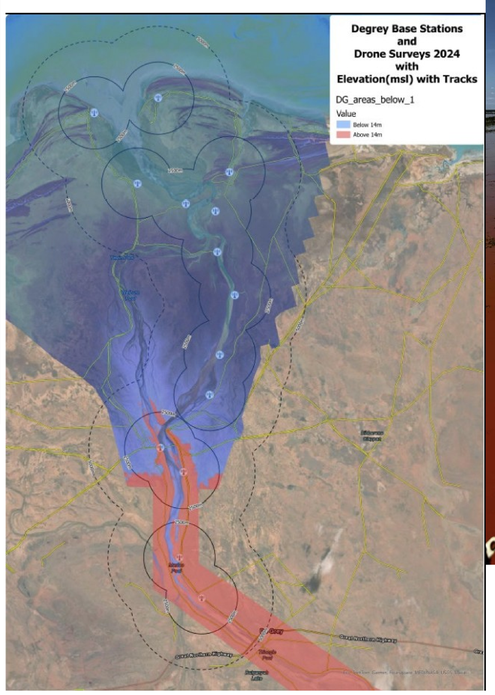
Methods

Shallow Augering and Percussion Coring: Allowed for the extraction of subsurface samples and providing a deeper profile of sediment layers.
Digging of Shallow Pits: Digging pits aimed to thoroughly examine the sediment profile near the surface and provide access to a more detailed sample analysis.
Ground-Penetrating Radar (GPR): Aided in exploring subsurface structures and layering, with enhanced accuracy of data to pin location coordinates.
Sediment Analysis/ USDA Classification/ Munsell Color Atlas: The use of these tools were primarily to classify the color and texture of the sediment that was observed/collected.
Grain Size Assessment/ Brunton Grain Size Card: These methods were specifically used to measure the size of gravel and sand particles. Much of the provided data displays depositional environment and sediment dynamics.

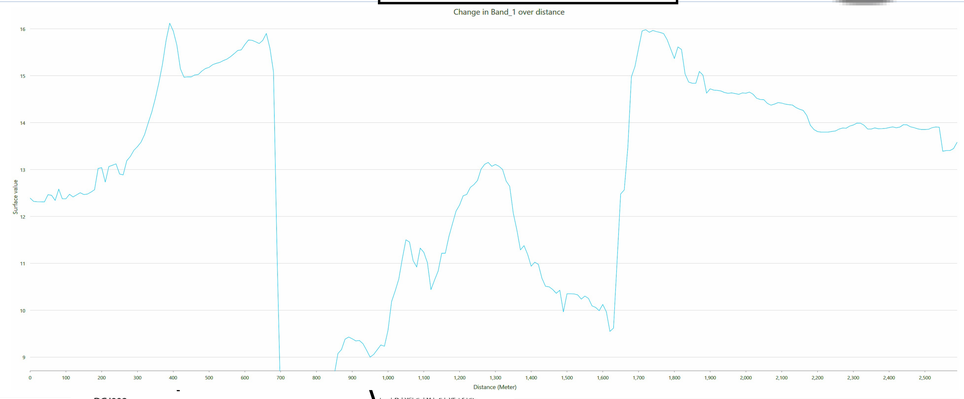
Obtaining an elevation

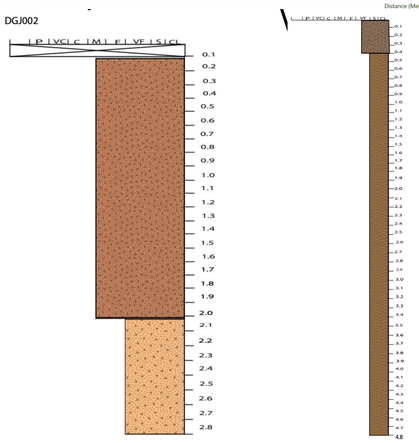


As we continued to auger toward our next objectives, one was conducted on the top of a levee (DGJ-002), while the other (DGJ-003) was measured a short distance away. However, the third auger was located in a deeper valley between both levees from the east and west to determine any differences in depth, texture, color, and any unique features.
After augering at both desired sites, I attempted to grasp an elevation profile from the 2nd auger to the middle of the delta to observe any



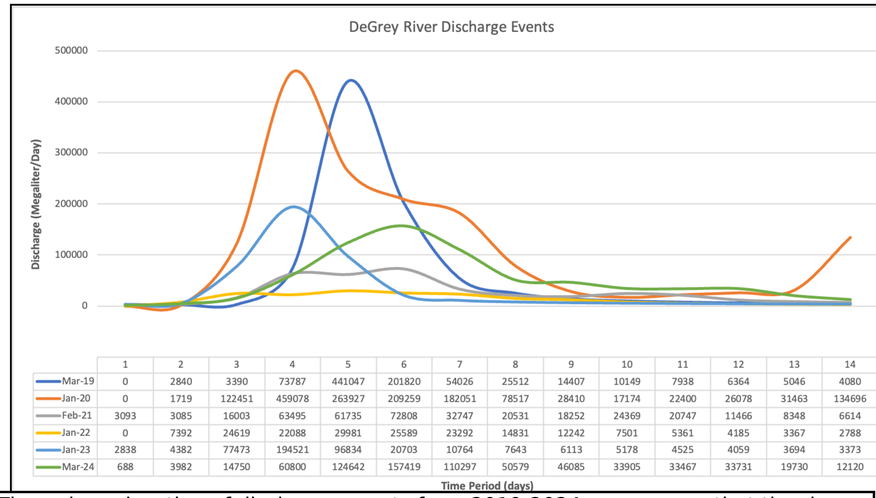
Elevation Profile





Significant fluctuations are shwon here throughout the obtained elevation profile. A sharp change in topography in in the beginning of the graph suggests that it could have been exacerbated by recent cyclonic activity, causing rapid water flow and subsequent erosion.
There may also be the case that a deep channel or erosion gully are present within the region as well. Following the sharp drop, the rest of the profile displays a gradual decline with numerous fluctuations, possinly indicating rolling terrain or a series of much smaller ridges and channeles that

Discharge



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mar-19	0	2840	3390	73787	441047	201820	54026	25512	14407	10149	7938	6364	5046	4080
Jan-20	0	1719	122451	459078	263927	209259	182051	78517	28410	17174	22400	26078	31463	134696
Feb-21	3093	3085	16003	63495	61735	72808	32747	20531	18252	24369	20747	11466	8348	6614
Jan-22	0	7392	24619	22088	29981	25589	23292	14831	12242	7501	5361	4185	3367	2788
Jan-23	2838	4382	77473	194521	96834	20703	10764	7643	6113	5178	4525	4059	3694	3373
Mar-24	688	3982	14750	60800	124642	157419	110297	50579	46085	33905	33467	33731	19730	12120

Through analyzation of discharge events from 2019-2024, we can see that the river carries its fullest amount of water during peak discharges. Veolocity can vary because of projected strength of water, causing erosion or deposition of sediment.
The initial levee formation typically occurs by the most amount of sediment deposition concentrated by the velocity, thus allowing for more build up of concentrated material on this levee. However, with the formation of a neigboring second levee, subsequent flooding events will allow for sediment to surpass the intial levee formed, and create an entirely new levee.

Conclusion

Our analysis of the DeGrey River levee systems appear to demonstrate the significant impact of discharge events on sediment deposition and levee formation. Much of the data displays a vivid relationship between increased sediment accumulation and high discharge volumes which are necessary factors for the stability of the levees. After investigating the unique nature of these processes, it was also shown that spatial and temporal variations underline levee system developmemt. These findings greatly emphasize the dynamic relations between levee formation and river discharges, driving the need for further investigations to