PRELIMINARY ANALYSES OF MARTIAN-TERRESTRIAL ANALOG RIVERS TO EXAMINE THE INFLUENCE OF SEDIMENT IN FORM-DISCHARGE RELATIONSHIPS.

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Background: Empirical form-discharge relationships derived from terrestrial rivers [e.g., 1,2] and scaled for difference in gravity, are commonly used to estimate flow discharges (m^3 s^{-1}) of Martian paleochannels [e.g., 3-7]. Discharge estimates are used in various models with implications for ancient climate [8-9]. Regression analyses of terrestrial channel form (e.g., width, wavelength) and discharge records produce form-discharge relationships: $Q_n=aX^b$, where Q is the discharge of a flood with a recurrence interval of n number of years, a and b are constants, and X is a measurement of form [1-2]. Bankfull discharge is recognized as the most effective flow for moving channel sediment over time, controlling channel form, and may be approximated by the Q_{2yr} [10].

Sediment size in the channel bed and banks has profound effect on the relationship between discharge and channel form [1]. Form-discharge relationships not specific to any category of sediment size (Table 1), refered to here as "non-specific" relationships, were derived from regression analysis of 252 channels with various sediment sizes (clays to cobbles) in the Missouri River Basin [1]. Equation 1 is the most commonly used relationship for estimating paleodischarge on Mars [3-7] because there is a dearth of information about fluvial channel sediments [11 & refs. therein]. Relationships derived from channels with specific sediment sizes, refered to here as "sediment-specific" relationships, are derived from analyses of 2 channels in the Sand Hills, NE (Eq. 2) and 15 mud-rich channels in the Missiour River Basin (Eq. 3) [1].

Table 1: Form-Discharge Relationships [from 1]

Eq.	Relationship	Sediment Type	Stand. Error
1	$Q_{2yr}=1.9W^{1.22}$	Non-specific	79%
2	$Q_{2yr}=0.031W^{1.86}$	Sand-dominated	26%
3	$Q_{2yr}=2.0W^{1.86}$	Mud-rich	52%

Terrestrial analogs provide helpful opportunities to test the relationships in Table 1 among channel form, discharge, and sediment size. The Usuktuk River on the North Slope, Alaska and Quinn River in the Black Rock Desert, Nevada (Figure 1) [12] have been investigated as potential analogs for meandering channels in the Aeolis Dorsa region, Mars [5,12,13], based on their well-developed meanders in permafrost and low-vegetation floodplains, respectively. These channels in Alaska and Nevada are sand-dominated and mud-dominated, respectively. How well do form-discharge relationships predict discharge in these well-sorted and possible analog channels?

Hypotheses: *Null:* The influence of sediment size on channel width for a given discharge is irrelevant across all sediment sizes. If true, this hypothesis would validate the common use of non-specific relationships. *Alternative:* The influence of sediment size on channel width for a given discharge is relevant across all sediment sizes. If true, this hypothesis would require the use of only sediment-specific relationships.

Methods: Hypotheses were tested by comparing records and/or models of Q_{2yr} and predictions of discharge derived from width measurements coupled with non-specific and sediment-specific relationships.

Although no gauge record exists for the Usuktuk River, it is a tributary of the Meade River. The Meade has a gauge record from 2006 to 2014 and has similar sediment and hydrological regimes as the Usuktuk [14]. We carried out the analysis using data from the Meade River. Discharges of peak streamflows for the Meade River at Atasuk, AK indicate the Q_{2yr} is 702 m^3 s^{-1} (waterdata.usgs.gov). There is no nearby gauge station for the Quinn River, NV, but we use an *in situ* estimate of bankfull discharge, 11.9 m^3 s^{-1} [15], as an approximation of the Q_{2yr}.

Observations of aerial photographs and digital elevation models of the North Slope of Alaska (5-m res.) and Quinn River (1-m res.) were made using ArcMap software. For both rivers, samples of channel width were made by measuring bankfull width every 500 meters of channel length. Bankfull width was measured as the distance between the abrupt change in slope, nearest to the channel, on opposite banks. Samples of channel width were coupled with a non-specific form-discharge relationship (Eq. 1) and the relevant sediment-specific relationship (either Eq. 2 or 3) to create distributions of predicted discharge.

Results: Measurements of bankfull width and estimates of Q_{2yr}, from the outputs of form-discharge relationships, are shown in Table 2.

Table 2: Average bankfull width & estimated Q_{2yr}

	Meade River, AK	Quinn River, NV
Bankfull width	248 m (σ=71.4 m)	15 m (σ=3.6 m)
# of widths	177	44
Q_{2yr}	702 m^3 s^{-1}	11.9 m^3 s^{-1}
Q_{2yr} (Eq. 1)	1600 m^3 s^{-1} (σ=565)	48 m^3 s^{-1} (σ=12)
Q_{2yr} (Eq. 2)	936 m^3 s^{-1} (σ=512)	n/a
Q_{2yr} (Eq. 3)	n/a	280 m^3 s^{-1} (σ=109)

Discussion: For the sand-dominated Meade River, the accuracy of discharge predictions *increased* when width measurements were coupled with the sediment-specific relationship rather than the non-specific relationship. In this case, the null hypothesis can be rejected and the alternative hypothesis can be accepted because the relationship between channel form and discharge is influenced by the properties and abundance of sand. Sand is the most mobile sediment, and causes large variation in channel width for a given flood discharge [1]. If channels on Mars are sand-dominated, conventional use of non-specific form-discharge relationships will overestimate Q_{2yr}.

For the mud-dominated Quinn River, the accuracy of discharge predictions *decreased* by coupling width measurements with the sediment-specific relationship compared to the non-specific relationship. In this case, the null hypothesis cannot be rejected. If channels on Mars are mud-dominated, use of non-specific form-discharge relationships will also overestimate Q_{2yr}.

Thus, in either case, these results indicate that discharge estimates on Mars made using non-specific relationships are overestimates.

Future Work: This work will be advanced by statistical analyses to determine the significance of differences between Q_{2yr} and discharge predictions from non-specific and sediment-specific relationships. New form-discharge relationships for mud-dominated channel (as opposed to mud-rich channels) may be derived from analysis of channels in the Basin and Range, NV.

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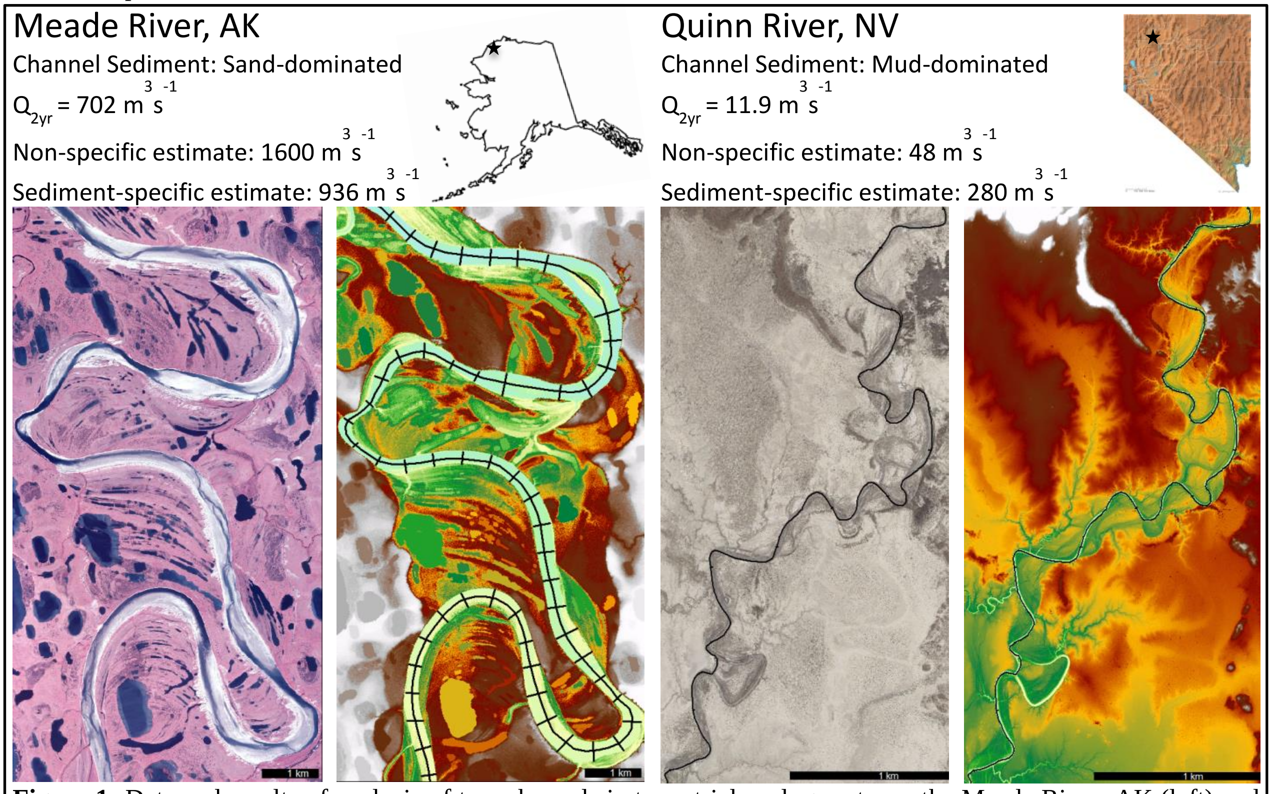

Figure 1: Data and results of analysis of two channels in terrestrial analog systems, the Meade River, AK (left) and the Quinn River, NV (right). Scale bars on each image are 1 km. An aerial image of the Meade River shows bright sandy bedforms in the channel. The infrared signal of vegtation appears "red" as false-color. The topographic image of the Meade shows scroll-bar ridges and thermokarst pounds in the surrounding floodplains. The aerial image of the Quinn River shows sparse vegetation around the channel. The topographic images of the Meade River and Quinn River have ~17 m and ~4 m of relief, respectively. Width measurements are shown in black.