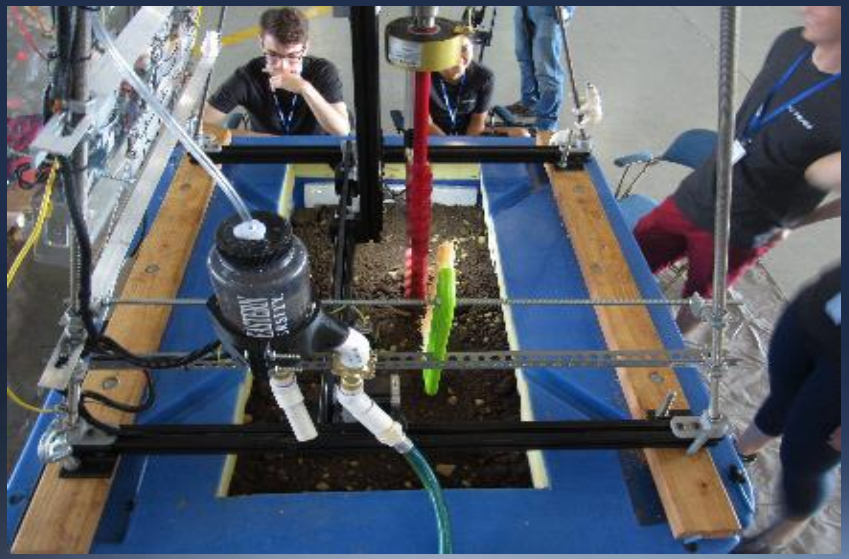
2019 Moon to Mars Ice and Prospecting Challenge Overview
Space Resources Roundtable 2019

Richard (Rick) Davis
SMD Assistant Director for Science and Exploration
NASA Headquarters

@redplanetrick

Creatively Using the Tools Available to Us

- Creative Partnerships (International and Commercial)
- Small Missions
- STEM Programs and Competitions
- Analog Missions
- Others??

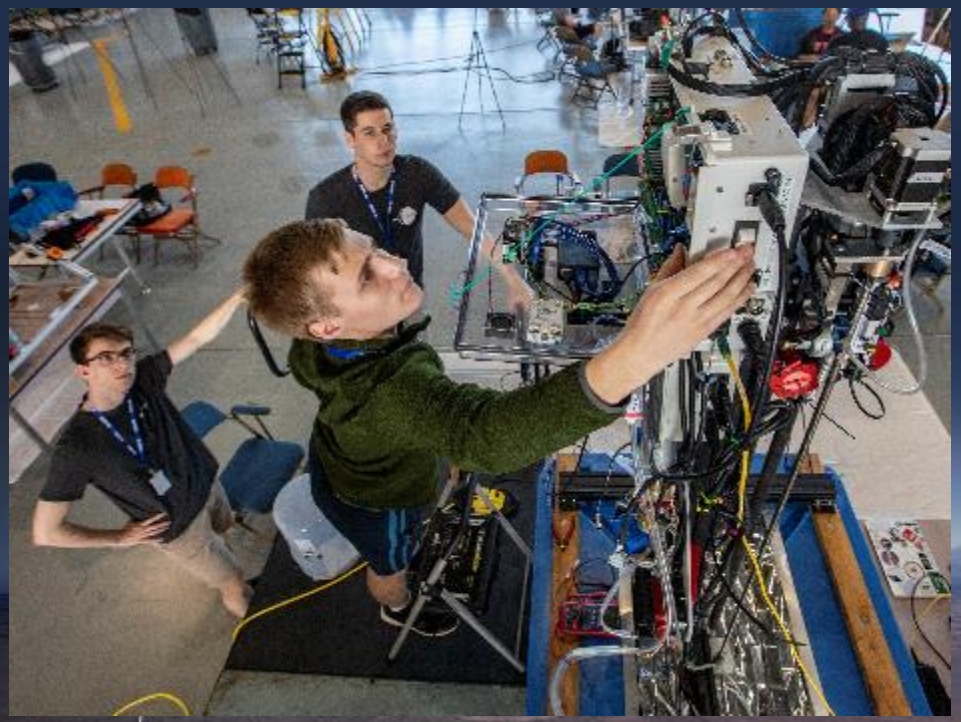


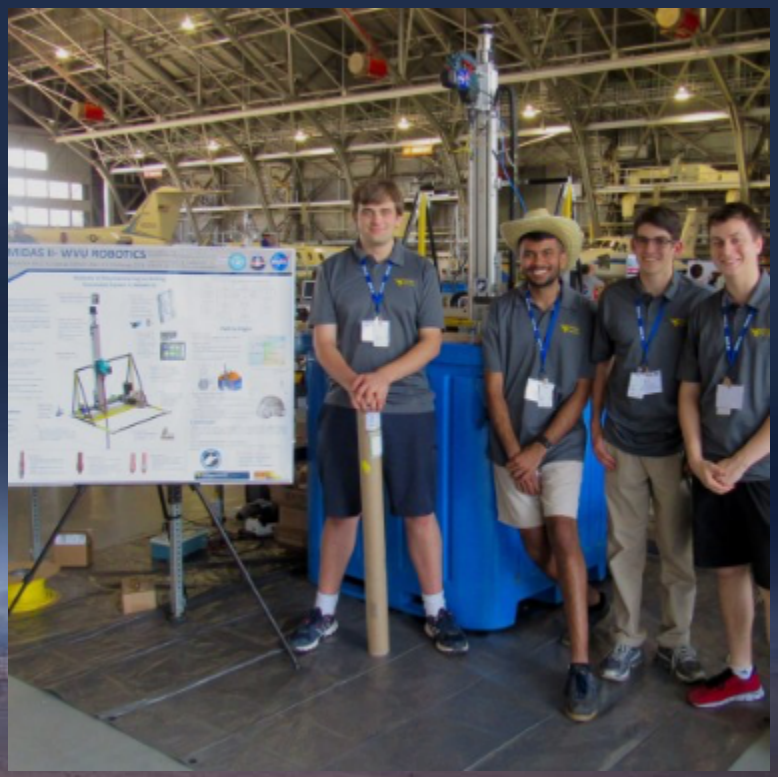
History of the Mars Ice Challenge

- Water is essential to a sustained human presence beyond Earth as we explore further into our solar system, therefore we must determine how to extract it.

- The myriad layers that may be present atop the ice can present different drilling challenges due to the varied composition, density, and hardness of each layer.

- Drilling systems must be able to identify and understand these layers/challenges and modify accordingly.





2019 Finalists

- Carnegie Mellon University*
- Colorado School of Mines*
- Massachusetts Institute of Technology
- Northeastern University
- Stevens Institute of Technology
- University of Houston
- University of Tennessee, Knoxville
- Virginia Polytechnic Institute and State University
- West Virginia University*

Winners and Progress

Awards from the 2019 Moon to Mars Ice and Prospecting Challenge

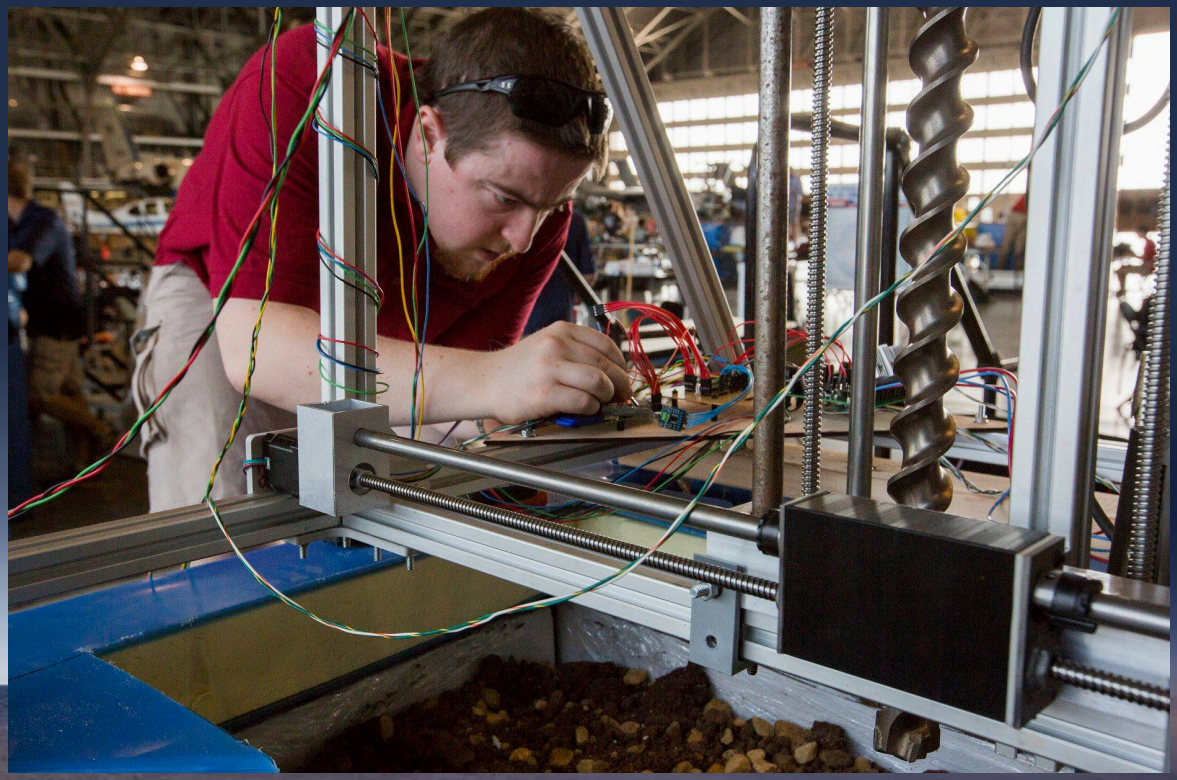
- Most Water Produced: West Virginia University
- Cleanest Water: Stevens Institute of Technology
- Most Accurate Digital Core: Stevens Institute of Technology
- Lightest System: Carnegie Mellon University
- Best Technical Paper: TIE Northeastern University and the Massachusetts Institute of Technology
- Runner-up: Stevens Institute of Technology
- Overall Winner: West Virginia University

Year of the Ice Challenge	Total Water Produced (mL)	Number of Teams Producing
2017	411.75	2 of 8
2018	4,311.5	5 of 10
2019	20,707	5 of 9

MARS

Big Takeaways After 3 Years of the Ice Challenge

- We are converging on the design for drills and water extraction
  - Rodwells have emerged as the standard for accessing the water
- Student competitions can make meaningful contributions to the field
- Collaboration is key to the design process
  - Each year the teams build on the shoulders of giants
- Multi-disciplinary teams are critical for making this effort a reality for Mars Missions



MARS

Major Lessons Learned

Penetrating the Overburden

- Percussion alone did not guarantee a success; rotation and percussion together was useful but it may depend on the drill bit
- A drill sleeve may only prove useful if drilling through loose material
- Augers have not proven effective yet
- Higher RPM was more effective than higher torque for rotation drills
- Temperature and Torque sensors should be included in the design of any subsurface ice drill

Operation and Implementation

- Integrated testing is crucial
- There is no one right way to get water
- Do not reinvent the wheel
- Create a multi-disciplinary team

MARS

Major Lessons Learned (con't)

Extracting Water

- Peristaltic pump is advantageous
- Include ability to reverse the flow to unclog filters
- Sand filtration beds seem to be the best method of water purification
  - Electrofloculation has not proven as effective

Characterizing the Overburden

- Cross-referencing data from multiple drill holes was useful
  - Trying to characterize the overburden, drill, and extract water all-in-one was really challenging
    - The challenge required using mechanical feedback to identify the layers, but that might not be the most effective method
    - Having foreknowledge (using a GPR for instance) could have helped
- Percussive drilling meant destroying the material and changing its properties

Miscellaneous

- 3D printing worked well in various areas
  - Weight reduction
  - Held up for duration of competition
  - Do not 3D print your drill bit
- Carbon fiber is good for structural elements
  - Lighter and stiffer than aluminum

MARS

For More Information

Visit our website:

http://www.nasa.gov/journeytomars/mars-exploration-zones

Follow us on Twitter:

@RedPlanetRick

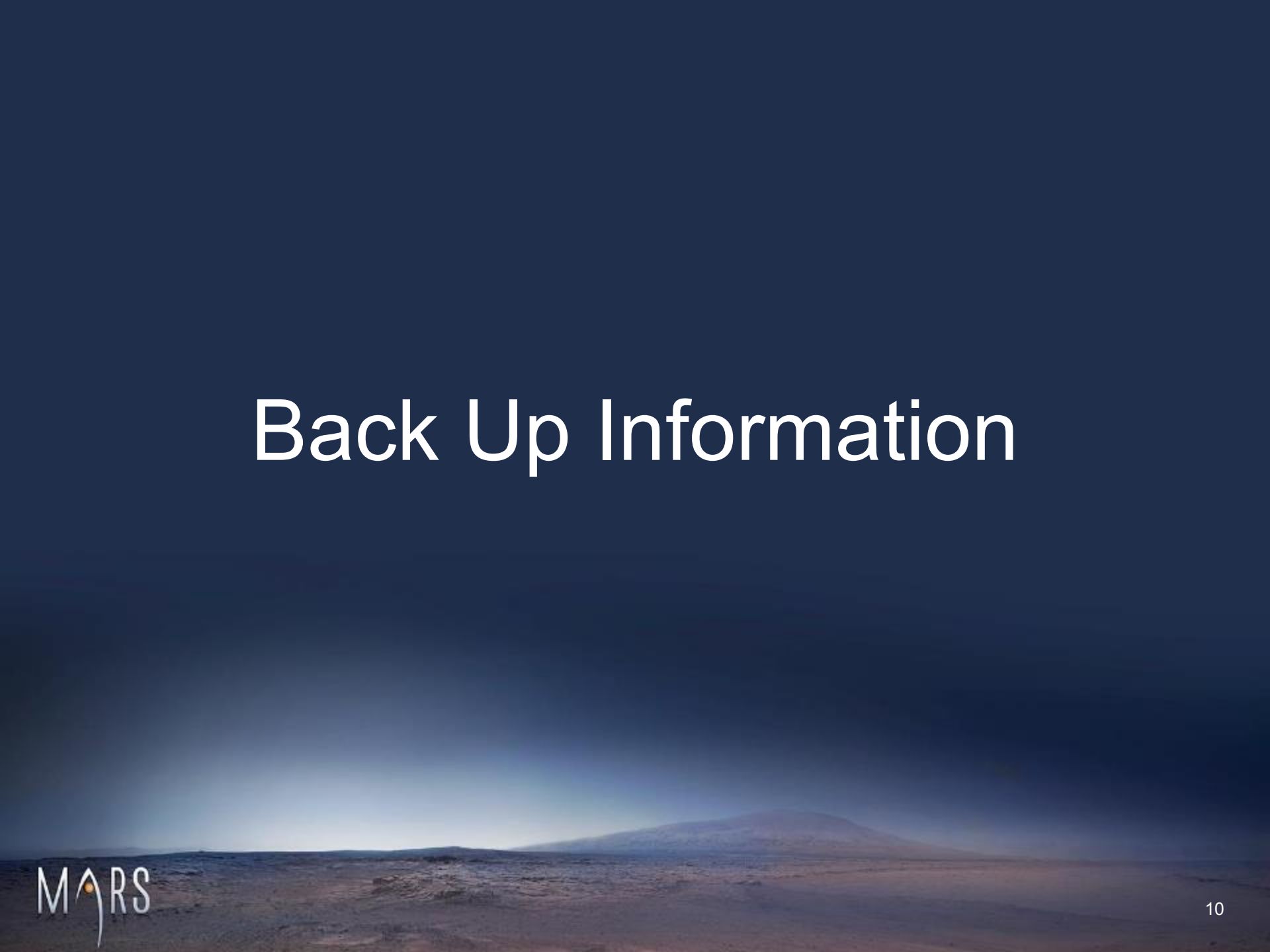
- and -

Join our distribution list, by contacting us at:

NASA-Mars-Exploration-Zones@mail.nasa.gov

MARS

Back Up Information



2019 Moon to Mars Ice & Prospecting Challenge Scoring Matrix

Teams must collect at least 50 mL of water to be eligible for the 1st or 2nd overall prize

Team:_____

Total Possible Points = 490 (*including 40 potential bonus points – see Prospecting Section*)					
Water Extraction (Max 180 points) – 40% of overall score	**"x"**	**Water Volume**	**Max Points**	**Actual Points**	**Comments/Notes**
Number of points assigned for hands-on water collection			25		
Number of points assigned for hands-off water collection			125		
Water Clarity			30		

Each team's water volume will be collected (separately for hands-off and hands-on periods) and measured at the end of each day. Silt that has settled to the bottom of the containers will also be measured at the end of the day and subtracted from the water volume measurements to give each team their total water volume for that day's hands-off and hands-on collections. The most total volume collected over the two day period by any one team in the following modes of operation = "x":

Scoring for hands-on water collection (Max of 25 points): The team with the most water collected during hands-off operations is given a score of 25. Other teams' points are scaled linearly: [(Team volume/x) *25]

Scoring for hand-off water collection (Max of 125 points): The team with the most water collected is given a score of 125. Other teams' points are scaled linearly: [(Team volume/x) *125)]

Scoring for water clarity (Max of 30 points): Teams will be awarded up to 30 points based on the clarity of the water extracted. Turbidity tests will be conducted at the end of each day, with points being awarded to each team's sample with the best clarity over the 2-day period. See Page 2

Prospecting: Drilling Telemetry (Max 90 pts) – 20% of overall score (+40 add'l bonus points available!)	**Max**	**Actual**	**Comments/Notes**
Identify the correct number of overburden layers	10		
Sequence the layers in order from softest to hardest	40		
Identify the thickness of each layer within an established margin of error (MOE)	40		
BONUS POINTS: Up to 40 bonus points will be awarded if teams can accurately determine the true hardness of individual layers in terms of MPa (within a 10% MOE)	**40**		
Technical Paper (Max 135 points) – 30% of overall score	**Max**	**Actual**	**Comments/Notes**
Quality of Path-to-Flight description, including rationale behind various trades and critical modifications made to the system for extracting water from sub-surface ice on Mars **and** prospecting on the moon.	45		
Technical quality, feasibility, and innovation of design for use off-Earth	35		
Quality of integration video and summary description	30		
Quality of summary of production and testing approach	15		
Adherence to Technical Paper guidelines	10		
Poster Presentation (Max 45 points) – 10% of overall score	**Max**	**Actual**	**Comments/Notes**
Discussion of the Earth system (How team got from here to the off-Earth system). **Note:** The Poster should be a summary of the technical paper with emphasis on modifications made for extracting water from sub-surface ice on Mars **and** prospecting on the moon.	25		
Technical Content, Style, Coherence	10		
Engagement with judges (all team members should participate) and quality of response to questions	10		

Water Extraction (max 180 pts) _____
Prospecting (max 90 pts) _____
Technical Paper (max 135 pts) _____
Poster Presentation (max 45 pts) _____
Bonus Points (max 40 pts) _____
Sub-Total Score _____

Note: In the event of a tie, total water volume collected may become the deciding factor.
(The team who collected the most water will emerge as the winner)

Continue to Page 2

2019 Moon to Mars Ice & Prospecting Challenge Scoring Matrix

Teams must collect at least 50 mL of water to be eligible for the 1st or 2nd overall prize

Penalties			
Penalty Points are deducted from a team's total score	Max Points	Points Deducted	Comments/Notes
Exceeding the Volume Limit (10 points off total score for every 1 cm over the size limit of 1m x 1m x 2m)	–		
Exceeding the Mass Limit (20 points off total score for every 1 kg of extra weight over the weight limit of 60 kg)	–		
Exceeding 9A Current/Amperage limit by blowing a fuse (80 points off total score and disqualification for the top prize)	80		
Failure to provide a WOB data logger that can provide real-time data (60 points off total score and disqualification for the top prize)	60		
Misalignment between what was proposed in the Mid-Project Review and/or Technical Paper and the system brought to the competition (up to 200 points off total score at the discretion of the judges)	200		
Solid debris in collection bag (1 point per 10 grams)	–		# of grams: Day 1_____ # of grams: Day 2_____
Excessive dirt outside of the 12' x 12' tarp under team test station (up to 20 points off the total score at the discretion of the judges)	20		

Sub-Total Score (1st page) _____

Subtract Total Penalty Points _____

Total Score _____

Scoring for Water Clarity

Scoring for water clarity (Max of 30 points): Teams will be awarded up to 30 points based on the clarity of the water extracted. Turbidity tests will be conducted at the end of each day, with points being awarded to each team's sample with the best clarity over the 2-day period.

NTU (Nephelometric Turbidity Unit): Measurement of Reflected Light from a Sample
Note: All samples with an NTU above 1,000 will be calculated using a dilution

Turbidity (NTU)	Points
Less than 5 NTU (Minimum Standard for Waste Water)	30 points
5.1 – 50 NTU	25 – 29 Points
51 – 1,000 NTU	20 – 24 Points
1,001 – 5,000 NTU	15 – 19 Points
5,001 – 25,000 NTU	10 – 14 Points
25,001 – 50,000	1 – 9 Points
Greater than 50,000	0 Points