MODULAR EXTRACTION TOOL FOR RIVERINE PLASTIC WASTE

DESIGN OF A PROOF-OF-PRINCIPLE PROTOTYPE

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THE OCEAN CLEANUP

APPENDICES

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APPENDICES

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APPENDIX 1: THE OCEAN CLEANUP CURRENT SOLUTION PORTFOLIO

At the time of this thesis, The River Team of The Ocean Cleanup possesses a solution portfolio comprising four distinct products. Among these, the Interceptor Classic and the Interceptor Tender are instrumental in waste extraction, while the Interceptor Barrier and the Interceptor Barricade are focused on containment.

The Interceptor Classic stands as the flagship of The Ocean Cleanup's river operations. It's strategically anchored in the center of the river, capturing and extracting all incoming debris. Employing a substantial conveyor belt, this system efficiently transfers the collected waste from the water onto a designated shuttle trolley. Subsequently, the waste is discharged into one of six sizable container dumpsters positioned on a separate barge. In the event that all dumpsters are filled, the barge is relocated to the shore, where a crane hoists the containers onto the land. A forklift then empties them into additional containers that are subsequently transported to recycling facilities or landfills.

In contrast, the Interceptor Barrier is engineered to direct floating waste toward a dedicated extraction point, typically the Interceptor Classic. By deploying one or two of these floating barriers, a funnel-like configuration is created, significantly increasing the volume of captured waste. The barrier is meticulously designed, with its lower edge extending down to approximately 50cm beneath the water's surface. This design ensures that high buoyancy plastics and similar objects are directed toward the Interceptor Classic, while marine life can safely pass underneath. In Jamaica, these barriers are effectively utilized to contain waste at the entrances of gullies (drain channels) by forming a moored U shape.

However, the debris contained within Jamaican gullies requires removal before it reaches the open sea. This task is efficiently handled by the Interceptor Tender, a small manned barge designed for waste extraction and offloading at the harbor. Given the proximity of multiple gullies equipped with barriers, the Interceptor Tender serves as an offloading vessel for several gullies simultaneously.

Lastly, the Interceptor Barricade has been recently deployed in Rio Las Vacas, Guatemala. This resilient floating barrier is engineered to withstand formidable forces, effectively halting waste during large flash flood events. Similar to the Interceptor Barrier, the Interceptor Barricade functions as a containment method, necessitating a separate extraction approach. The interceptor Barricade is strategically positioned at an angle, directing waste toward one shoreline, where it can be efficiently extracted using an excavator.

APPENDIX 2: EXISTING IN-WATER-WASTE INTERCEPTION TECHNOLOGIES

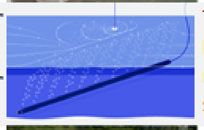
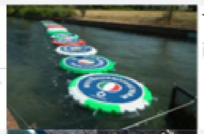
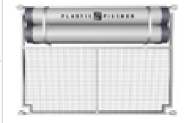
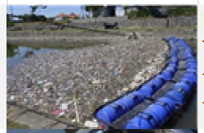
Table 1 provides an overview of various in-water waste interception technologies, although it doesn't cover all existing options identified in the analysis. Instead, it presents selected examples that represent broader categories of technologies. The fourth column offers a description of these categories, while the fifth column displays the number of solutions within each category. While this thesis primarily focuses on developing a specific extraction technology, it's essential to investigate the associated containment methods required to redirect and contain the debris before extraction. The comprehensive list of in-water waste interception technologies is available in Appendix 21.

These technologies can be categorized into three main groups: concentration, containment, and entrapment. Concentration involves redirecting waste to a specific location, containment prevents debris from flowing further downstream (although it may still return under certain conditions), and entrapment ensures waste cannot escape in any direction, providing a larger window of opportunity for extraction. For example, technologies in groups 1, 2, and 3 in Table 1 focus on concentrating debris for extraction, while those in groups 9, 10, 11, 12, 13, and 14 are designed to trap waste. Entrapment technologies are often combined with concentration methods to increase the area over which debris is captured. Technologies in groups 4, 5, 6, 7, and 8 primarily serve as containment barriers, stopping debris from flowing downstream. They can also aid in concentration, but their main advantage lies in creating a retention zone independently, preventing waste from passing the barrier.

Given that the objective of this thesis is to develop an extraction mechanism compatible with in-water waste interception technologies, it's crucial to assess compatibility. For mobile deployment strategies, a retention zone must handle significant waste quantities to maximize impact or extend time between extractions. In cases with large retention zones, entrapment isn't practical, and concentration alone contradicts the purpose of a mobile system. Therefore, the extraction mechanism should align with containment methods.

Containment methods often comprise a series of plastic buoyant objects filled with air or foam. Some versions include a metal or rubber bottom plate for improved penetration and debris capture. Wider versions prevent rolling over and twisting and also allow workers to walk on the barrier, facilitating waste redirection towards the extraction mechanism without entering the water.

The shape of the retention zone can be chosen based on the extraction mechanism. For instance, in Jamaican gullies, barriers are positioned in a U shape, directing waste to the center of the barrier, making it easy for extraction using the Interceptor Tender. Placing the barrier in a J shape would lead to waste accumulation near the shore, enabling easier direct-to-shore extraction. If the barrier is under high tension, a slash-shaped configuration can be created, optimized for concentration like the Interceptor Tender but requiring more effort and robust materials and tools. Realistically, the extraction tool designed in this thesis will likely be used with a J-shaped barrier, which should be adequate for reaching waste from the shore. Flow direction is a more significant limiting factor, as the tool typically enters from the shore at close to a 90° angle in relation to the flow direction. While this can be mitigated in complex ways, the tool's human-operated nature suggests some manual labor may be required. This becomes more manageable if the design is combined with a walkable barrier. While walkable barriers exist, most have drawbacks. The incorporation of a walkable The Ocean Cleanup barrier would facilitate deployment at currently unsolved sites. Combining a mobile extraction mechanism with a walkable barrier would ensure seamless deployment and enhance the impact of both developments.

		Product name & Company name	Picture	Description	# of similar solutions found
Concentration	1	Concentration Module River Recycle		This barrier is made of a band around two cylinders that spin it around. This moves the waste to one shore where it can be extracted.	0
	2	The Great Bubble Barrier The Great Bubble Barrier		This barrier is made out of bubbles. A tube with holes is placed at the bottom that creates a curtain of bubbles if air is pumped through. It redirects low buoyancy waste if it's light enough. This means boats can still navigate the water. It only works with slow flow speeds.	2
	3	River cleaning solution River Cleaning (MOLD S.R.L.)		This barrier is a long metal structure that is placed in the water. On top it has rotating wheels pushing the waste to one side of the river.	0
Containment	4	Interceptor Barrier The Ocean Cleanup		Barrier made from rubber strip with floaters on one or both sides. The Interceptor Barrier from the Ocean Cleanup is specially designed for waste concentration in stead of oil containment. The barrier penetrates deeper and the floaters have a low centre of gravity to prevent tipping.	8
	5	Tuffboom Worthington Products Inc.		This barrier is commonly used for oil spills. It floats on top of the water and has barely any coverage underneath the surface.	10+
	6	BB20 - Debris Master Worthington Products Inc.		This barrier is made of drums or other rotation moulded floaters. These types of barriers are made for higher flow speeds or even flash floods. The extra floaters on the back prevents the system from tipping over.	2
	7	Plastic Fischer barrier Plastic Fischer GmbH		This type of barrier uses PVC tubes as floaters and has a fence or net at the bottom to catch more waste. Plastic Fischer and Sungai watch both use this construction method to make barriers locally.	3
	8	Walker Sungai Watch		Made locally from water barrels, large drain pipes, nauticubes, etc.. These barriers are specifically made to be able to walk on. This makes the clean-up process easier. There are no specific companies producing these barriers, but they are often used by local organisations.	5
Entrapment	9	Seabin V5 The Seabin Project		This litter trap is placed just below the water surface but a pump is used to pump the water out of the container. This also creates a flow towards the container, resulting in verry high buoyancy waste flowing in.	3
	10	EnviRo Enhancer DESMI Ro-Clean A/S		This type of litter trap is very common. The water flows through ant waste gets trapped in the mesh or net. Some versions have barriers directing the litter into the trap. Pretty much all of them need to be emptied by hand or get towed to the harbour.	10+
	11	LittaTrap ENVIROPOD Canada Limited		This trap is similar to other litter trap but can be emptied directly from the dock. In theory you can place all litter traps next to the dock to make emptying easier. But this one specifically can be emptied by lifting up the net through a hatch in the floor of the dock.	10+
	12	Ultramarine/Cobalt Ichthion Ltd.		This litter trap is different than others since it creates flow, pulling the litter in with a rotor. The advantage of this system is that it can catch wate with different buoyancies based on the depth it's placed in.	0
	13	Trash trap Anacostia Watershed Society		In this case, a metal mesh is placed at an angle in the water. With high water the waste gets pushed up to the top. If the water level drops again, the waste stays on the mesh where it can be picked off.	0
	14	StormX Netting Trash Trap Storm Water Systems Inc.		These nets can be placed in a stream if a full coverage barrier is placed with the right sized holes in it as shown in this example. Originally it was made for drain pipes. Like other litter traps the waste gets filtered out by the netting. The whole nets can be removed and emptied.	3

APPENDIX 3: EXISTING EXTRACTION TECHNOLOGIES

Table 2 provides an overview of operational direct-to-shore extraction technologies, with one technology chosen to represent multiple similar ones in the table. Non-operational and non-direct-to-shore extraction technologies are examined to ensure a comprehensive industry overview but are not further discussed in the main report. The complete list of technologies, along with detailed notes and sources, can be found in Appendix 22.

The most common working mechanism, as shown in Table 2, involves the use of a conveyor belt in the majority of existing direct-to-shore extraction solutions. Some alternatives employ a rake (11), seesaw (7), or lift mechanism (8).

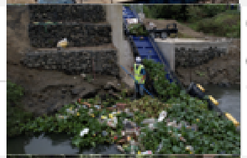
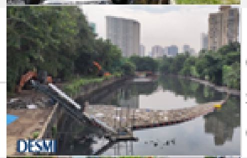
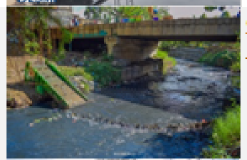
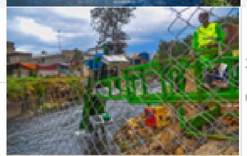
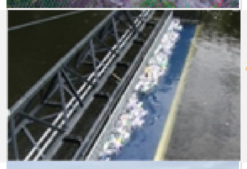
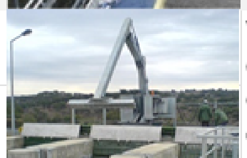
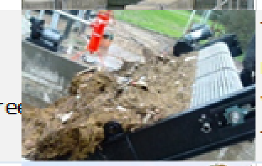
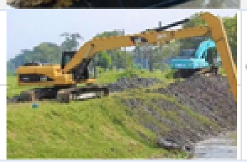
Solutions 11 and 12 are specifically designed to filter debris from water before it enters power plants or processing facilities. This is essential to prevent turbine or pump clogging. In such cases, water flows beneath a perpendicular structure that serves as an offloading site above the water level. In contrast, other mechanisms offload waste at the river's edge, making them suitable for a wider range of sites and cost-effective because they don't require structures built above the water for offloading.

Regarding pricing, most companies are not particularly transparent about the cost of their technologies, and specific numbers cannot be disclosed in this thesis. However, the commercially available extraction mechanism with the lowest price still exceeds $40,000, which appears relatively affordable compared to some other available options. Some systems can cost hundreds of thousands of dollars, including high installation expenses.

The DESMI Rise with elongation, built on top of a DESMI Rise, is likely to be more expensive. Conversely, commercially unavailable solutions tend to be more cost-effective. For instance, The Ocean Cleanup had a lengthy conveyor belt produced locally in Indonesia for transporting crates from the Interceptor Classic's offloading dock to trucks. Since this conveyor is solely a transport belt for buckets and doesn't extract waste from the water, it's not included in the analysis. However, its production and installation cost was approximately €5,000.

Chemolex's solutions fall in the €5,000 to €10,000 range. Notably, they deployed 12 machines at 12 different locations in May 2023 (Personal communication, May 12, 2023). In theory, if a single mobile solution or components of the solution could be utilized for multiple sites, it could significantly reduce investment costs.

Regarding mobility, it's important to note that there are currently no fully mobile solutions available. The Azure system, for instance, is designed to be mobile as it's built on top of a trailer. However, to ensure its proper functionality, a concrete ramp (as depicted in Figure 28) had to be constructed on-site. This requirement somewhat restricts the overall mobility of the device.

	Product name & Company name	Picture	Description
1	River Recycle technology River Recycle		Double conveyor system floating on a large raft. First conveyor extracts waste from the water, second conveyor transports it to high quey side.
2	Azure system Ichthion Ltd.		Conveyor lowered in the water with a truck via a constructed ramp. Camera at the top uses algorithm to identify different types of waste.
3	Rise DESMI Ro-Clean A/S		Small scale version of the River Recycle technology with second conveyor leaning on low quey so scaffolding is
4	Rise with elongation DESMI Ro-Clean A/S		Locally elongated version of the DESMI Rise. Same use case as River Recycle technology but cheaper. Keeps small raft while using the quay as support for the second conveyor.
5	Extraction System A Chemolex Ltd.		Small locally produced conveyor to move the waste from the water to the shore. Used for low riverbank
6	Extraction System B Chemolex Ltd.		Baskets connected to a single chain turn around to scoop out the waste from above. Long arm used to walk over and move the waste to the shore.
7	Extraction System C Chemolex Ltd.		Turning seesaw mechanism to scoop the trash out of the water and drop it on the shore by rotating it around the
8	Extraction System D Chemolex Ltd.		Basket on a manual pully and slider to lift the trash out of the water and drop it on the shore.
9	Sea protector one All in on green		Metal barrier contains waste, once full, the complete arm lifts up including a conveyor belt that was
10	K-series - atriculated boom Muhr		Waste that flows underneath a structure like a bridge or dam is stopped by a large metal screen. This screen is cleaned by a large mechanical rake, dropping the waste on the top of the structure.
11	Debris removal screen International Water Scre		This screen is used in similar situations as the Hydro rake. However, instead of a static screen in combination with a mechanical rake, the screen is a conveyor, turning to move the waste to the top of the structure.
12	Excavator Several companies		Excavators are often used to extract the trash from the contained area of a large log boom.

APPENDIX 4: SITE SPECIFIC CHARACTERISTICS DEFINITION

Besides technologies, the different situations and use cases have to be analysed. Since every river is different, it is important to focus on a certain type of site. Developing a system that can be used at all sites is unrealistic and would be more complex and expensive than it needs to be for most. Some characteristics that might make a system good for one site would even make it worse for others.

Every potential deployment site can be described with certain parameters. In cooperation with engineers of the river team of The Ocean Cleanup, a list of river site characteristics is compiled. This list consists of characteristics that would affect what kind of system is needed if any. The full list can be found in appendix 19. Since this project focusses on extraction from a pool of already contained waste, the characteristics that only impact containment like river width and amount of traffic can be excluded. Next to that, there are some characteristics like land ownership or exposure to public opinion that might affect if a system is placed at a site, but won't affect the functional requirements for a direct-to-shore system. Lastly, characteristics like accessibility by land and flooding risk of the offloading site are excluded since The Ocean Cleanup is only interested in deploying systems at one end of the range. There is enough impact to be made at sites that are accessible by land and have a low flooding risk of the offloading site for example, so for now, these characteristics can be assumed to be at one end of the range for the development of a new system.

This leaves the following river site characteristics that affect the functional requirements of a direct-to-shore extraction mechanism:

A correlation matrix (see Appendix 20) is filled out by multiple employees of The Ocean Cleanup in order to find what characteristics are completely separate or unpredictable and what characteristics could be correlated and therefore grouped in one overarching characteristic. This grouping leads to the following overarching characteristics for deployment site categorization:

[a]	Amount of waste	[i]	River depth near shore
[b]	Waste composition	[j]	River bank/bed composition
[c]	Size of waste	[k]	River flow speed
[d]	Water's edge accessibility on foot	[l]	River flow consistency
[e]	River bank occupation	[m]	Salinity
[f]	River bank inclination	[n]	Tidal range
[g]	Distance water level to offloading site – horizontal	[o]	Flow direction
[h]	Distance water level to offloading site – vertical	[p]	Water quality (chemical pollution)

Tidal/rainfall effects

Some characteristics are connected to each other with few to no exceptions, like tidal range [n], flow direction [o] and salinity [m]. These can all be grouped under tidal effects. Tides also effect flow speed [k] and consistency [l] since the direction and speed is constantly fluctuating. However, these characteristics can also be impacted by rainfall resulting in completely different situations. These characteristics [k,l] are part of tidal effects, but should also be considered outside of the tidal point of view.

River bank construction and total distance from the water to the offloading site

Other characteristics can be grouped together under river bank construction, which consists of two sub-groups; constructed channels with steep shores and natural rivers with sloping shores.

Constructed channels with a steep angled shore in relation to the water surface (50-90°) [f] are made of hard materials like concrete or stones [j], have a small horizontal distance from the water to the offloading site [g], and relatively deep water near the water's edge in relation to the overall depth of the river [i]. The vertical distance from the water to the offloading site [h] depends on tidal effects or rainfall but is often large to prevent flooding which makes it harder to reach the water's edge on foot [d].

Natural riverbanks are formed or made with a shallow angle in relation to the water surface (10-50°) [f], which makes it easier to access the water's edge on foot [d]. Natural shores are often made of softer natural materials like sand or clay [j] and have shallow water near the water's edge [i]. The horizontal [g] and vertical [h] distance from the water to the offloading site differs per site, however, the vertical distance is often smaller since the water does not only get higher but also wider due to the angle of the shore. This results in a much larger difference in volume with a relatively small vertical distance.

There are some exceptions, but based on the experience of The Ocean Cleanup, these groupings of characteristics can be made for a lot of streams. The river bank inclination and the horizontal/vertical distance from the water to the offload site can differ greatly, but the combination of these two can be used as an indication for the other characteristics.

River bank occupation [e] is also expected to be correlated with the riverbank construction since constructed channels are almost exclusively found in urbanised areas, while there are mainly natural shores in rural areas. However, there are a lot of natural shores in urbanised areas as well. The field research in Malaysia (Appendix 6) shows some prime examples of this. Due to the large amount of exceptions to this division, this characteristic does not seem to be a main indicator for other characteristics.

Amount and type of waste

The last group of characteristics all have to do with the waste. Amount of waste [a], waste composition [b], size of waste [c], and water quality [p].

The size and composition of the waste are often hard to estimate on the basis of other characteristics. The size of waste that reaches a barrier is partially impacted by flow speed and width of the stream but this can change with rainfall or per season. The waste composition can also change per season. A high percentage of plastics is preferable since a business model could be built around it. However, other anthropogenic waste (waste caused by humans) should also be extracted. So, only if there is a lot of natural organics mixed in with the waste, a more manual approach might be beneficial. Ultimately, it is best to design for as much variation in size and composition as possible and make changes in operations to accommodate for the site specific situation and seasonal differences.

Chemical waste or water quality is not clearly correlated with other characteristics. However, with the choice of materials it should be assumed that the water will contain some chemical pollution. Therefore it will not create different categories in the deployment sites.

The design should take these unpredictable characteristics into account no matter what. The amount of waste however, is an important factor to take into account since this could have a large impact on the use case.

Main characteristics for site categorization

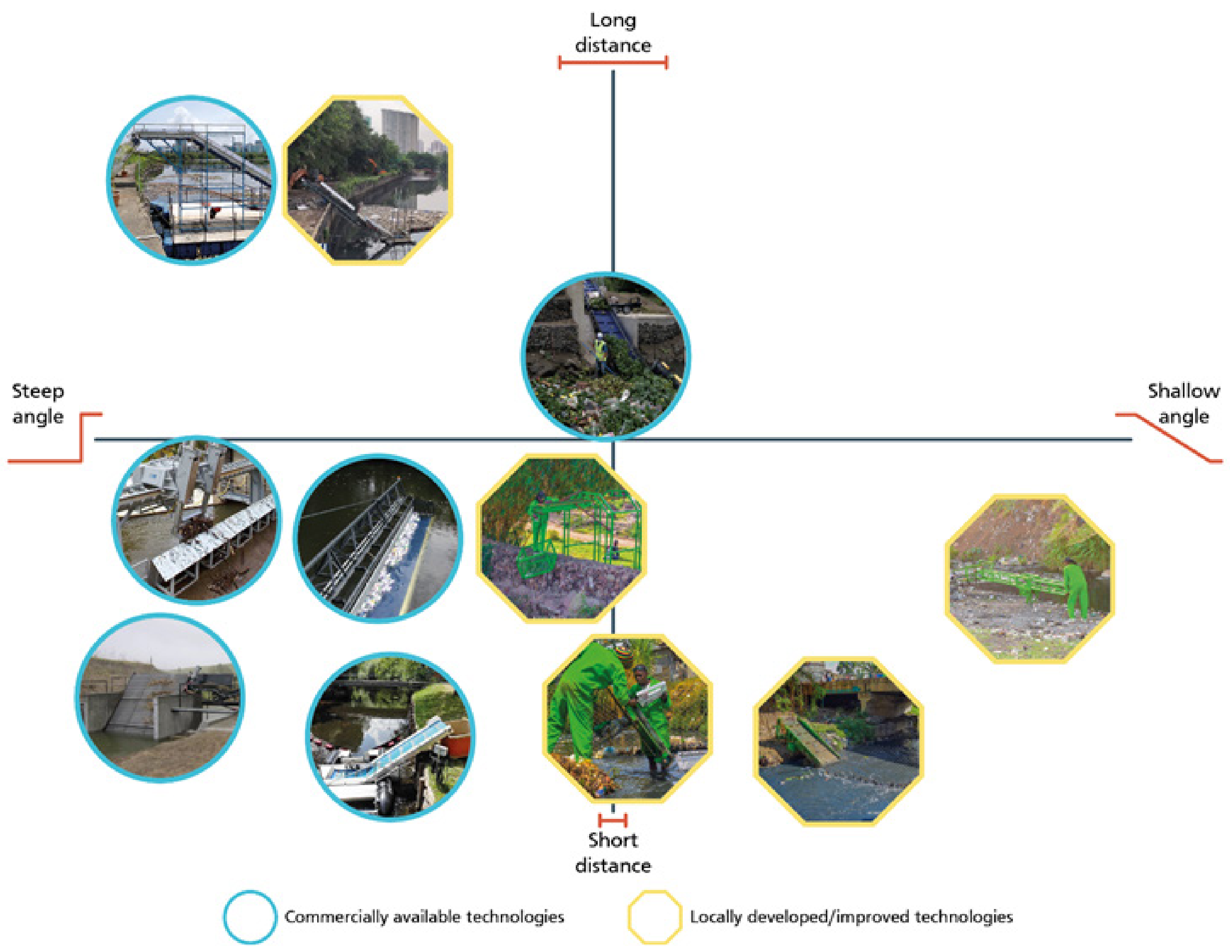
All characteristics mentioned above impact the design requirements. However, the most important characteristics that can be used to classify sites in categories that might benefit from different solutions are the following:

- *Tidal/rainfall effects*
- *River bank inclination*
- *Total distance from the water to the offloading site*
- *Amount of waste*

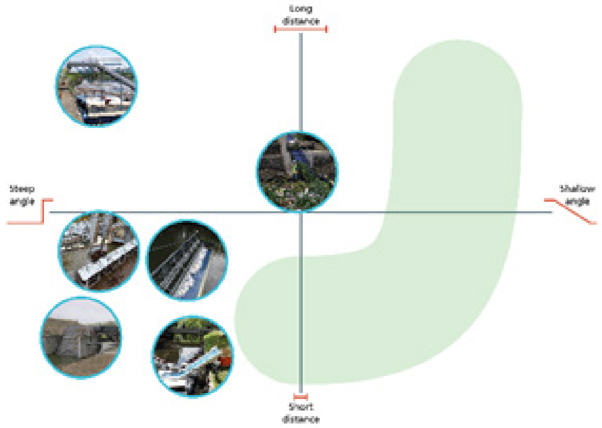
APPENDIX 5: CATEGORIZATION OF EXISTING DIRECT-TO-SHORE EXTRACTION TECHNOLOGIES

As mentioned above, river sites can be categorized based on the four main characteristics. From these four characteristics, 24 different categories can be derived (3×2×2×2). Every characteristic is defined with two options, for example, high and low amount of waste. The only exception is tidal/rainfall effects since there are tidal rivers, non-tidal rivers, and rain dependant rivers. Of course, both tidal and non-tidal rivers can be heavily impacted by rainfall but in order to keep the smallest amount of categories, only the extremities are included. The differences in situation due to the amount of waste and tidal/rainfall effects can be addressed by changes in the design, but might also be addressed by operational changes. For example more waste can be extracted with a larger or faster mechanism, however, it could also lead to more frequent extraction with the same mechanism. This makes it harder to categorize external existing technologies based on these characteristics. The first step in categorization of existing technologies will rely on the characteristics that have the most direct and obvious impact on the physical appearance or technical aspects of a design, which are river bank inclination and distance from the water to the offloading site.

In Figure 29, the existing technologies are categorized based on river bank inclination and total distance from the water to the offloading site. The commercially available technologies have a blue circular border while the locally made/improved technologies have a yellow octagonal border.



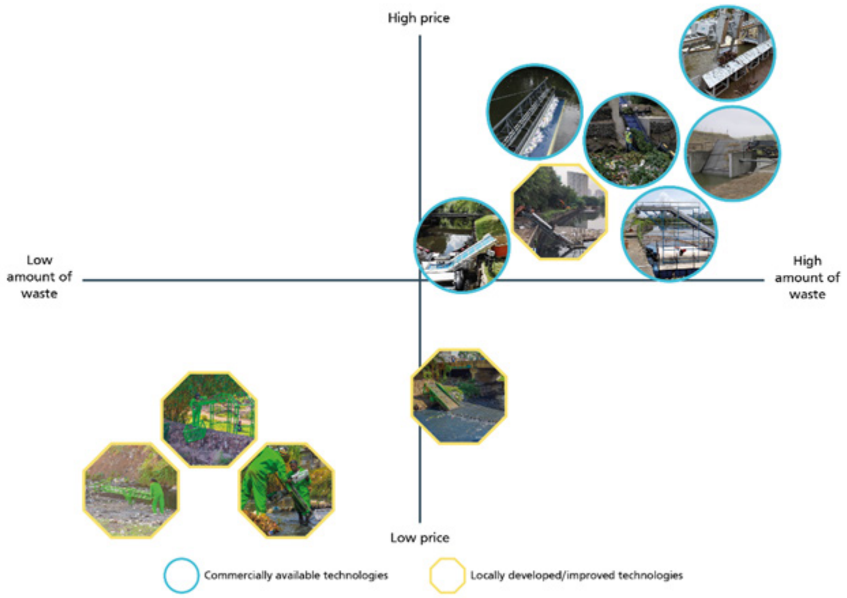
If the locally developed/improved technologies are excluded, all existing direct-to-shore technologies are focussed on shores with a steep angle in relation to the water surface. When excluding locally developed solutions, there is a clear opportunity as visualised in Figure 30. The fact that there are only locally developed technologies found in this category during the analysis phase of this thesis shows that there is a need for it but that there are no commercially available solution that fits the use case or budget.



When looking at the amount of waste that can be extracted with the existing direct-to-shore technologies, all the commercially available technologies are physically capable of extracting large amounts of waste. The limiting factor is operational efficiency. If they are capable of extracting high amounts of waste, they can theoretically also be used to extract less. However, these technologies are too expensive to use on sites with a lower amount of waste. In order to be appealing for locations with less waste per site or an inconsistent waste stream, the price should be low or the mechanism should be able to service several sites in order to spread the cost. In Figure 31, the correlation between price and amount of waste they are deployed for is visualised. Since not all data is publicly available, some estimations had to be made.

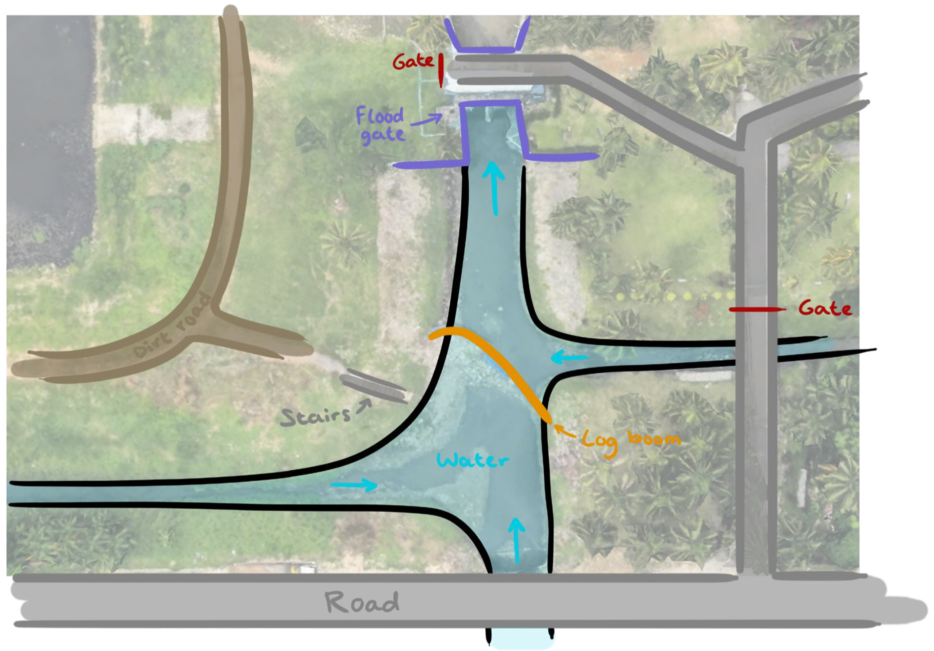
The idea of developing a mobile extraction technology that can be used at multiple sites was received well within The Ocean Cleanup. There was no existing commercially available solution found in the analysis phase, meaning that it could be an interesting opportunity for The Ocean Cleanup.

Later on in the project, when researching solutions from other industries, there were some companies discovered that produce aquatic weed harvesters and weed cutters. Some of them also make pier/shore conveyors that can transport cargo from their weed harvesters to a truck. These conveyors are mobile and able to get wet, however they are not meant to extract water plants from the water. The weed harvester extracts the water plants and drops it on the pier/shore conveyor to transport it to the truck. This is most likely the reason why they are not used for waste extraction directly from the water.



APPENDIX 6: MALAYSIA RIVER SURVEY RESULTS

TRIBUTARIE #1 PERSIARAN SERI JUNJUNG



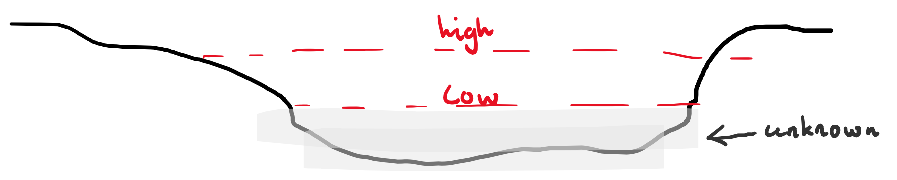
1. **Is the riverbed natural or constructed?**
   Semi constructed. The shape is natural, but it is reinforced with stones and a metal mesh.

2. **What material is the shore made of?**
   Rocks and mesh on top of silty clay.

3. **What material is the riverbed made of?**
   Silty clay.

4. **What is the angle of the shore?**
   Around 15°.

5. **What is the estimated cross section of the riverbed?**



6. **What is the width of the river at low tide?**
   17 meters.

7. **What is the width of the river at high tide?**
   22 meters.

8. **What is the flow speed (estimate)**
   0 m/s.

9. **Describe the flow of the river?**
   No flow. Still slow flowing when flood gate is opened. Only after heavy rain will the flow speed be significant.

10. **Is there a good offloading location?**
    Yes, verry good. The container standing there was about 8 meters from the water. Next to the container there is a road and a patch of flat ground.

11. **Are the roads suited for heavy equipment?**
    There is a well-maintained dirt road leading to the offload site.
    The site can be accessed by a small RORO truck (shown by the RORO bin that is placed at the site).

12. **Is there trash in the tributary?**
    Yes, quite a large build up.

What kind of trash is there?
PET, Polystyrene foam, soft plastics, footballs, wood, water hyacinths, coconuts.

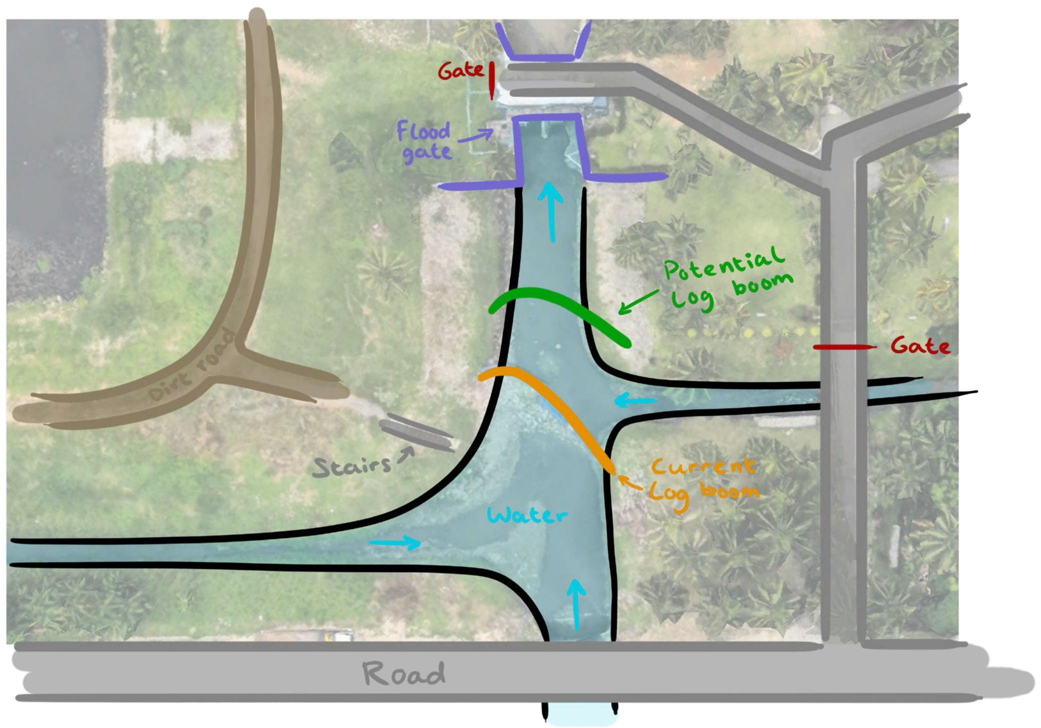
What is the size of the trash?
5-50cm (polystyrene boxes are the largest items).

Is there a lot of biological trash (plants)?
About 50%.

What kind of vegetation is there?
Grass and low shrubbery.

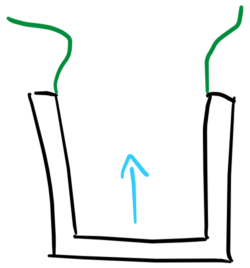
Recommendations:
There is already a log boom deployed at this site. Currently they take it out by hand, however, the site would be perfect for a DTS system. Since there is not that much trash per tributary, this system could be driven around and used at different tributaries where trash is contained.

The location of the log boom could be improved to include one more water way. However, to do so it needs to be places on one shore where we don't know who it belongs to. It is a bit further away from the stairs, but with a DTS this is not that important anymore. The RORO bin can also be placed closer to the flood gate without issues.



TRIBUTARIE #2 JALAN KERAPU

1. **Is the riverbed natural or constructed?**
   Constructed with a natural mouth to the Klang.



2. **What material is the shore made of?**
   Concrete and hard reeds at the natural end.

3. **What material is the riverbed made of?**
   Not visible, but probably silty clay.

4. **What is the angle of the shore?**
   90°.

5. **What is the estimated cross section of the riverbed?**
   Unknown.

6. **What is the width of the river at low tide?**
   4 meters at the flood gate fanning out to about 20 meters natural shore before flowing into the Klang.

7. **What is the width of the river at high tide?**
   4 meters at the flood gate fanning out to about 20 meters natural shore before flowing into the Klang.

8. **What is the flow speed (estimate)**
   0 m/s.

9. **Describe the flow of the river?**
   The area before the flood gate is residential and hard to get to, so collecting it behind the flood gate at the connection to the Klang seems the best solution. There can be flow from the tributary if the flood gate is opened. Otherwise, there can be fast flowing water flowing past in the Klang resulting in some turbulent current in the section between the main river flow and the flood gate.

10. **Is there a good offloading location?**
    No. Hard to get close to the water and there is no room for proper offloading.

11. **Are the roads suited for heavy equipment?**
    Yes.

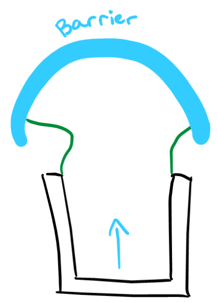
12. **Is there trash in the tributary?**
    Mainly on the shore which seems to be washed up from the Klang with high high tide.

13. **What kind of trash is there?**
    PET and some small foam takeout boxes.

14. **What is the size of the trash?**
    10-20 cm.

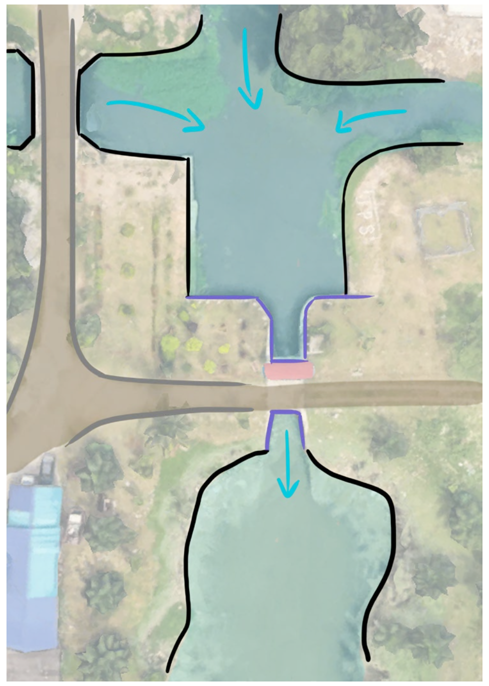
15. **Is there a lot of biological trash (plants)?**
    No.

16. **What kind of vegetation is there?**
    Dense bushes and trees with reeds at the waterside.



18. **Recommendations:**
    If a Jamaican gully style solution can be placed in this river, this would be the best solution for this tributary. It is hard to get access at another way then from water, so collecting it at the junction would be preferred.

TRIBUTARIE #3 JALAN PALEMBANG



Situation sketch

Overview in relation to the Klang

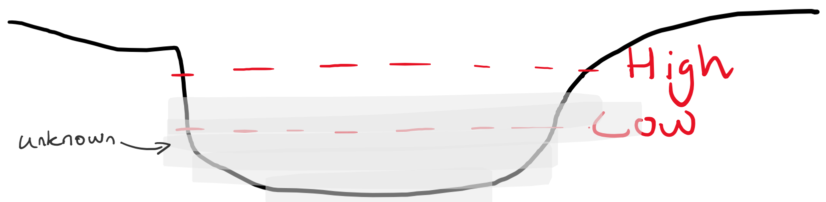
1. **Is the riverbed natural or constructed?**
   Semi constructed. One side is natural (the side with the JPS letters) and the other side is a straight drop supported with metal mesh. Behind the flood gate it's all natural.

2. **What material is the shore made of?**
   Silky clay and metal mesh on top on one side in front of the flood gate.

3. **What material is the riverbed made of?**
   Silky clay.

4. **What is the angle of the shore?**
   15-20°.
   With low water, the beginning can be steeper. On the other side the shore is about 90°.

5. **What is the estimated cross section of the riverbed?**



6. **What is the width of the river at low tide?**
   20 meters before the flood gate and might be as low as 10 meters behind the flood gate (not every situation is observed). The flood gate itself is about 4 meters wide.

7. **What is the width of the river at high tide?**
   21 meters before the flood gate and about 30 meters behind the flood gate.

8. **What is the flow speed (estimate)**
   0 m/s when the flood gate is closed. Flow speed is dependent on rainfall and timing of opening the gate.

9. **Describe the flow of the river?**
   Mostly static, only flowing when flood gate is opened and with heavy rain. Behind the flood gate, it is impacted by the high and low water from the river. However, current seems to not impact the area between the Klang and the flood gate a lot.

10. **Is there a good offloading location?**
    There is a reasonable offloading location. Good road access and some semi-flat ground at 10 to 19 meters from the water. Dependant on muddiness the bin can be dropped 10 meter from the water or right next to the road at about 19 meters.

11. Are the roads suited for heavy equipment?
    Yes.

12. Is there trash in the tributary?
    It seems quite clean. Trash flux will probably be higher with rain. The area around the water seems well maintained and probably often cleaned.

13. What kind of trash is there?
    Mainly some PET bottles floating around.

14. What is the size of the trash?
    10-20 cm.

15. Is there a lot of biological trash (plants)?
    No.

16. What kind of vegetation is there?
    Grass and some low reeds at the water side.

19. Recommendations:
    This site seems to be quite clean, but if it turns out it would be beneficial to contain and extract trash here, there are multiple options. A DTS system can be deployed before the flood gate. There is a basin where the 3 streams collect in where a barrier can be placed. Behind the flood gate, there is also a location where you can get to the water with the same system which is also good to reach with a truck. It could be treated as a gully and offloaded from the water. Finally there could be done some experimental technique to collect from the tributary and Klang at once. With a diagonal barrier behind the flood gate the trash from the tributaries could be directed to the right where it could be taken out with a DTS system. However, When trash flows from the Klang towards the flood gate, trash can be directed towards the other side. Here you can also collect it with the same modular DTS system.

TRIBUTARIE #4 JALAN MUHIBBAH

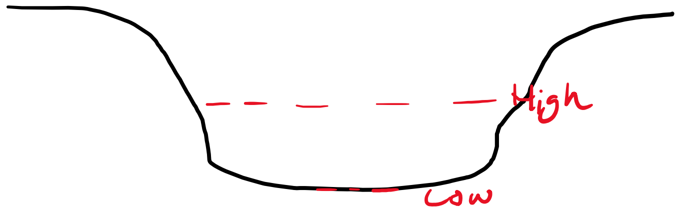
1. Is the riverbed natural or constructed?
   Mixed. Natural at two access points and constructed at the centre drain and around the flood gate.

2. What material is the shore made of?
   Silty clay with some stones (10-100 cm).

3. What material is the riverbed made of?
   Silty clay.

4. What is the angle of the shore?
   20-30° close to land. With low water the steep ending to the water could be around 60°.

5. What is the estimated cross section of the riverbed?



6. What is the width of the river at low tide?
   4 meters (low low tide is a stream of 30 cm wide or even no water at all but the vegetation on the side of the riverbed stops at 4 meters wide suggesting water flowing there quite often).

7. What is the width of the river at high tide?
   6m wide.

8. What is the flow speed (estimate)
   When we were visiting the first time about 0.2 m/s.
   Second visit with a bit more water (about 0.4 m/s).

9. Describe the flow of the river?
   Rain dependant (drainage).
   Only enough flow to move plastic after heavy rain.

10. Is there a good offloading location?
    No obvious offloading location. There is room to place a container close to the road, but it is about 20-25 meters from the optimal containment location, crossing one of the streams completely. Small size offload would be possible with modular DTS system, however, it's a complex location.

11. Are the roads suited for heavy equipment?
    5m wide asphalt with small but annoying bumps.
    Light heavy like small RORO trucks can access the area.

12. Is there trash in the tributary?
    Not that much since the visits were low tide, however, there was definitely some trash that was flooded through the second time we visited.

13. What kind of trash is there?
    Polystyrene foam, PET, soft plastics, water hyacinths.

14. What is the size of the trash?
    5-30cm (polystyrene boxes are the largest items).

15. Is there a lot of biological trash (plants)?
    About 30%.

16. What kind of vegetation is there?
    Bushes and trees at river access. High grass and bushes at the tributaries.

20. Recommendations:
    My recommendation for this site would be to not tackle it. It is a verry complex site with a lot of streams and poor access to the water. A trash fence and rake could be places just before the flood gate, however, the access needs to be improved to offload on top of the flood gate. The main access to the side is on the other side of one of the streams, meaning you have to cross a lot of water and land to offload. If this site needs to be tackled, it could be done on the Jamaica gully way.

TRIBUTARIE #5 KANDIS 1

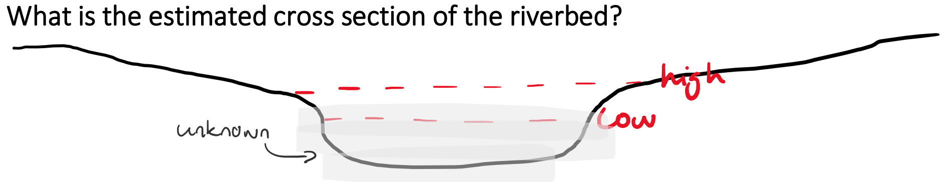
1. Is the riverbed natural or constructed?
   Natural.

2. What material is the shore made of?
   Silty clay loam.

3. What material is the riverbed made of?
   Silty clay.

4. What is the angle of the shore?
   10-15° at the water side, goes up to about 20-25° near the road.

5. What is the estimated cross section of the riverbed?



6. What is the width of the river at low tide?
   As low as 3 meters (estimated) before the flood gate and about 10 meters behind it.

7. What is the width of the river at high tide?
   8 meters before the flood gate and up to 14 meters behind it.

8. What is the flow speed (estimate)
   Between 0 and 0.3 m/s.

9. Describe the flow of the river?
   There is only flow from the tributary if the flood gate is opened. Otherwise, there can be fast flowing water flowing past in the Klang resulting in some turbulent current in the section between the main river flow and the flood gate.

10. Is there a good offloading location?
    Yes. The river is quite far from the road so there needs to be a long-distance transportation method towards a container. Shortest distance is 10 meters but the optimal place to get access to the water is 26 meters from the road. A RORO truck could drop the bin from the road but the gras besides the road is not verry flat so it cannot be placed far from the road without some changes to the landscape. It would be quite inexpensive to regrade the area and create a location closer to the water where the truck can drop the bin off.

11. Are the roads suited for heavy equipment?
    Yes. The only way to get there is an unpaved road which is quite bumpy. However, the road is used for the large RORO trucks that collect the trash from the large log boom next to the tributary, so it doesn't seem to be an issue.

12. Is there trash in the tributary?
    There is no trash in the water. On the shore there is some trash but that could be washed up from the Klang or dumped at that location by locals.

13. What kind of trash is there?
    PET, soft plastics like plastic bags, and polystyrene foam.

14. What is the size of the trash?
    10-30 cm.

15. Is there a lot of biological trash (plants)?
    No.

16. What kind of vegetation is there?
    Grass, weeds, and a few low bushes.

21. Recommendations:
    This site could be tackled gully style. However, the access from land is also good. This means an angled barrier/boom can also be placed and the trash can be extracted on the side. Since there is a distance of 10 to 26 meters between the water and a place where a container can be placed (dependant on the location of extraction and route to the road), a long distance DTS can be used. This could be the same system as used at Persiaran Seri Junjung and Kandis 2 (the next chapter). Since all these locations are on the same side of the river and Kandis 1 and 2 are even next to each other. This system could be deployed in turn at these sites.

TRIBUTARIE #6 KANDIS 2

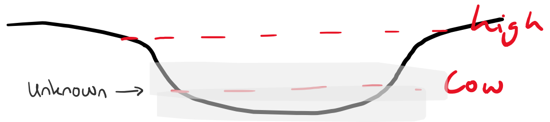
1. Is the riverbed natural or constructed?
   Natural apart from the concrete around the flood gate.

2. What material is the shore made of?
   Silty clay.

3. What material is the riverbed made of?
   Silty clay.

4. What is the angle of the shore?
   40-50°, quite steep but short drop-off.

5. What is the estimated cross section of the riverbed?



6. What is the width of the river at low tide?
   8 meters.

7. What is the width of the river at high tide?
   10 meters.

8. What is the flow speed (estimate)
   0 m/s.

9. Describe the flow of the river?
   Static until flood gate is opened. Flow is dependent on rainfall.

10. Is there a good offloading location?
    Yes. Verry close to the road (you can place a RORO bin as close as 3 meters from the water)

11. Are the roads suited for heavy equipment?
    Yes.

12. Is there trash in the tributary?
    No, it seems quite free from trash before the flood gate. Behind the flood gate there is more trash which can also originate from the Klang.

13. What kind of trash is there?
    PET bottles, plastic bags and polystyrene foam take out packages.

14. What is the size of the trash?
    10-20 cm.

15. Is there a lot of biological trash (plants)?
    No.

16. What kind of vegetation is there?
    Grass and reeds.

22. Recommendations:
    This site is quite easy to solve since the access is verry good, you can get verry close to the water and the infrastructure could even be linked in that of the Kandis log boom. The DTS system that can be used at Kandis 1 can also be used here. The barrier needs to be connected to the start of the concrete wall, leaving enough room for an extraction method on the patch of grass just before that.

TRIBUTARIE #7 JALAN MAT RAJI 1

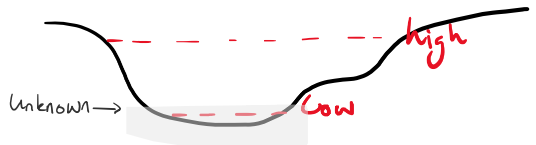
1. Is the riverbed natural or constructed?
   Natural.

2. What material is the shore made of?
   Silty clay.

3. What material is the riverbed made of?
   Silty clay.

4. What is the angle of the shore?
   40-50°.

5. What is the estimated cross section of the riverbed?



6. What is the width of the river at low tide?
   2 meters.

7. What is the width of the river at high tide?
   4 meters in the tributary before the merge of the last flow, 7 meters wide 'basin' before the flood gate.

8. What is the flow speed (estimate)
   0 m/s.

9. Describe the flow of the river?
   When we were there, it was quite dry so no current at all. However, it might flow with rain and the flood gate opened.

10. Is there a good offloading location?
    At the beginning there is. Later, one extra water way merges so if you want to catch as much trash as possible you want to contain and extract there. However, then the truck needs to drive over grass for about 200 meters. It is verry flat and seems meant for a car, but some road upgrades might be necessary.

11. Are the roads suited for heavy equipment?
    For the first possible offload site it is. The second needs some work to make it suitable. Maybe a small RORO truck can drive there as it is, but with rain or ware it seems best to lay down gravel for example.

12. Is there trash in the tributary?
    Yes. Since it's quite small, it seems unlikely that a lot of trash flows through this tributary, but there was quite some washed up trash on the banks.

13. What kind of trash is there?
    Plastic bottles, plastic bags, and polystyrene take out containers.

14. What is the size of the trash?
    10-20 cm.

15. Is there a lot of biological trash (plants)?
    No.

16. What kind of vegetation is there?
    (High) grass and reeds.

23. Recommendations:
    This tributary is not verry easy to access at the end. You can reach it with a DTS in the beginning at the side of the road, but further from the road and closer to the Klang it might be difficult to get to with a truck when the grass is wet. Since there is another tributary joining close to the Klang it seems strange to extract the trash before that. Besides that, Jalan Mat Raji 2 is right next to this tributary while there is probably another DTS technology needed for this one (see next chapter). This would make it way more logical to solve both tributaries at the same time with one Jamaican gully style barrier at the connection to the Klang.

TRIBUTARIE #8 JALAN MAT RAJI 2

1. **Is the riverbed natural or constructed?**
   Constructed. High quay.

2. **What material is the shore made of?**
   Concrete.

3. **What material is the riverbed made of?**
   Concrete.

4. **What is the angle of the shore?**
   90°.

5. **What is the estimated cross section of the riverbed?**
   Unknown. Probably squared off concrete at the constructed portion. After that it transitions in an unknown natural shape.

6. **What is the width of the river at low tide?**
   9 meters.

7. **What is the width of the river at high tide?**
   9 meters.

8. **What is the flow speed (estimate)**
   0.2 m/s.

9. **Describe the flow of the river?**
   Will flow faster with rain. There is no flood gate since the whole tributary is constructed of concrete to be able to handle the high and low tide.

10. **Is there a good offloading location?**
    The same location as Jalan Mat Raji 1 can be used. However, since there is a large vertical difference between high and low water, the steep quay needs a specific direct to shore solution. Another option might be closing off the mouth (Jamaica gully style) and get it out with an interceptor tender from the Klang.

11. **Are the roads suited for heavy equipment?**
    Same roads as Jalan Mat Raji 1.

12. **Is there trash in the tributary?**
    Only some small bits and pieces. Might be a lot after heavy rainfall.

13. What kind of trash is there?
    Some bottles and plastic bags.

14. What is the size of the trash?
    5-20 cm.

15. Is there a lot of biological trash (plants)?
    No.

16. What kind of vegetation is there?
    Grass.

24. Recommendations:
    Since there is no flood gate at the end of this tributary, there is a large height difference between low and high water. This makes it not verry suitable for a DTS system even though you can get really close to the shore with the road. The vertical drop is just quite large. Catching it at the connection to the Klang seems more logical. Both Jalan Mat Raji 1 and 2 can be contained with one barrier. Tis barrier is however only accessible from the water.

TRIBUTARIE #9 JALAN SENANGIN

1. Is the riverbed natural or constructed?
   Constructed around the drain exits. It flows through a natural riverbed before meeting the flood gate. This natural bank is very uneven and jagged.

2. What material is the river bed shore made of?
   Concrete and loam.

3. What material is the riverbed made of?
   Silky clay.

4. What is the angle of the shore?
   90° (at least on the constructed sides where the drain exits. This location has the most potential for containment and extraction which will be explained in the recommendation).

5. What is the estimated cross section of the riverbed?
   Concrete squared off in the relevant location.

6. What is the width of the river at low tide?
   5 meters.

7. What is the width of the river at high tide?
   5 meters.

8. What is the flow speed (estimate)
   0 m/s at the time of visit.

9. Describe the flow of the river?
   It is the exit of a storm drain so it only flows after heavy rain.

10. Is there a good offloading location?
    Yes. Above the drain exits, there is a good spot on the side of the road to park a truck that can lift trash up and load it onto the truck.

11. Are the roads suited for heavy equipment?
    Yes.

12. Is there trash in the tributary?
    Yes, there is some trash.

13. What kind of trash is there?
    Plastic bottles and bags.

14. What is the size of the trash?
    10-30 cm.

15. Is there a lot of biological trash (plants)?
    No.

16. What kind of vegetation is there?
    Grass, bushes, and trees around the natural riverbed.

25. Recommendations:
    This tributary would be perfect for drain trash nets.

There is a good location above the drains to lift them out. Easy access and cheap to install. Going another route on this location would be illogical.

TRIBUTARIE #10 JALAN SELUANG

1. Is the riverbed natural or constructed?
   Constructed before the flood gate and natural behind it.

2. What material is the shore made of?
   Concrete or silty clay.

3. What material is the riverbed made of?
   Concrete or silty clay.

4. What is the angle of the shore?
   90° before the flood gate and 10-40° behind it.

5. What is the estimated cross section of the riverbed?
   The bottom is made from concrete so it is probably quite flat. Some broken off slabs were lifted up that could be seen sticking out at low water so nothing can be assumed.

6. What is the width of the river at low tide?
   28 meters.

7. What is the width of the river at high tide?
   28 meters before the flood gate and there are parts behind it that widen to 40 or even 70 meters.

8. What is the flow speed (estimate)
   0 m/s. The Flood gate was closed. Behind the flood gate there also seemed to be little flow. The rise and drop of the water level in the river influences the flow, however, the current in the river seems to have little effect on this area close to the flood gate.

9. Describe the flow of the river?
   It is made for a lot of drainage, so the current can be high when there is a lot of rain.

10. Is there a good offloading location?
    Yes. Wide flat grass areas on each side before the flood gate. Behind the flood gate it is harder to get to and will need to be done some construction/changes to the area in order to access it.

11. Are the roads suited for heavy equipment?
    The roads are large and relatively well maintained. To get to the offload side there is a ramp down from the road. However, around the river there is grass which might not be optimal for heavy vehicles. With some easy changes it could be very suited. Behind the flood gate there is no clear route to the water side, so this should be constructed if there needs to be extracted on that side.

12. Is there trash in the tributary?
    Barely. Some plastic bottles on the surface of the water.

13. What kind of trash is there?
    PET bottles.

14. What is the size of the trash?
    10-20 cm.

15. Is there a lot of biological trash (plants)?
    No.

16. What kind of vegetation is there?
    Well maintained grass.

26. Recommendations:
An angled barrier can be placed before the flood gate in this tributary to direct the trash towards one shore. A system like the DESMI rise can be used to get it on the shore where a RORO truck can get to via the ramp to drop and pick up a bin.
Another option might be to place a system that can trap the trash from both sides behind the flood gate. This could be a location to test systems that can catch up and down stream trash. However, my advice would be to stay before the flood gate since this area is already quite good for extraction and offloading.

APPENDIX 7: MAIN FINDINGS FROM CONVERSATIONS WITH (EX)-OPERATORS IN MALAYSIA

- *Since there are a lot of tributaries, the extraction device needs to be easy to transport, set up, and break down in order to use the same device for multiple tributaries. This saves a lot of cost and reduces the risk of being stolen or vandalized. The system is only deployed when extraction is needed. This can be once a week or once a month depending on the rainfall and amount of waist.*
- *Every situation is different so the more modular/ adaptable the better.*
- *In order to set up an efficient infrastructure the extraction needs to be executed by a company that does not contract out different parts of the operations but does it all in-house.*
- *Placing the bin further away from the water is rarely an issue, closer to it is not always possible. The bin can sometimes be placed right next to the water, only needing to transport the trash 3 to 4 meters. More often, the trash needs to be transported about 8 to 10 meters and for some locations even up to 28 meters. Some distances might be too large to cover in the scope of this project, but if longer distances than 10 meters need to be accommodated for, other solutions may be advantageous.*
- *Keep the concept as low tech (but high impact) as possible. More moving parts means more points where it can break down. Issues with interceptor belt shows harsh circumstances.*
- *Keep it cheap to keep the entry threshold low. Makes it more attractable for third parties to clean the rivers using this technology.*
- *Local manufacturing would keep cost down and stimulate local involvement and economy.*

APPENDIX 8: SELECTION CRITERIA SURVEY

Name: ....

The following criteria will be used to select what extraction methods have the most potential in the following use scenario:

The extraction technology is meant for small scale extraction of contained waste. It is to be used by local operations in small streams (think around 20 meters wide) with a natural shore that has an angle between 10 and 50 degrees relative to the water surface. Due to the relatively low amount of waste per extraction site, a single device will be developed to be used at multiple sites (like the Interceptor Tender but than on land), thus it needs to be easy to transport between sites and suitable for different sites with varying angles.

The first criterium is used as example. Since it is of high importance in order to make the final design desirable and viable in the intended use case, it scores a 5 out of 5.

In the right column you can tick the box if the criteria was especially difficult to rate importance.

	Criteria	Explanation	Importance 1-5	
A	Ease of operational transportation	Easy transportation of the technology from one site to another or to storage	5	☐
B	Ability to handle a large variety of waste	Transport items with a large variety in size or weight for example (think of candy wrappers vs water hyacinths of $1m^2$)		☐
C	Automation of operation	How much manual labour is still allowed during setup and operations? (5 = automation is important)		☐
D	Compatibility to different barriers/containment syst	How important is it that the system can be used with different containment methods?		☐
E	Compatibility with big bag (or other bags)	System can be used with big bags or other types of small scale containers		☐
F	Compatibility with RORO bins	System can be used with different sizes RORO bins		☐
G	Compatibility with standard vehicles	Transportation on locally available vehicles or can it be transported by a modified or custom vehicle?		☐
H	Distance it can realistically transport waste	The distance from the waterborne waste to the offload area		☐
I	Ease of setup	The work that needs to be done in order to deploy the technology at a site		☐
J	Ergonomics	Ergonomics of the deployment (weight, size, handles, etc.)		☐
K	Extraction rate	... kg per min (5 = fast extraction rate is of high importance)		☐
L	Freight transportation	If it is manufactured in another country, should it be designed for easy and cheap transportation? (5 = important to take freight transport into account)		☐
M	Improved sanitary safety	In comparison to manual clean-up efforts. How important is it that workers won't come in contact with 'polluted water?		☐
N	Lack of civil modifications	5 = of high importance that there are no civil modifications needed at the extraction site		☐
O	Local assembly	System can be assembled locally like the Interceptor Barrier for example		☐
P	Local maintenance	Maintenance can be done by the local organisation or local partners		☐
Q	Local manufacturability	Manufacturability/assembly can be done locally		☐
R	Low cost	If the technology needs to be used by local operations, it should be relatively low cost		☐

	Criteria	Explanation	Importance	
S	Manufacturability	For example taking complexity of machining methods or specialty machines that are needed for production into account (5 = it is of high importance to take manufacturability into account)		☐
T	Materialization of final design	5 = taking the availability, suitability, price and other aspects of the required materials into account is important		☐
U	Modularity of assembly	Modularity of the components that make up the complete extraction mechanism in order to quickly assemble and repair them		☐
V	No or only basic tools required for deployment	How important is it that the workers can deploy the technology with the least amount of tools?		☐
W	Off the shelf components	How important is it that parts can be bought off the shelf instead of producing them specifically for this technology?		☐
X	Potential to be modified for different use cases	Potential to be modified to also suit quey sides or extra long horizontal distances for example		☐
Y	Safety of the device	Danger that the worker is exposed to by working with the technology		☐
Z	Setup time	Time needed to deploy at a extraction site (5 = fast setup time is important to take into account)		☐
AA	Simplicity	Simplicity of the mechanism (easy to understand for repairs)		☐
AB	Suitability for extreme rain events	How important is it that the system can withstand a flash flood (4m/s flow for example)		☐
AC	Suitability for riverbank variation	Natural shore lines all look slightly (or largely) different. How important is it that the technology is suitable for different angles and shapes of shores?		☐

	Suggestions for criteria (or room for other notes)	Explanation	Importance	

APPENDIX 9: RESULTS OF SELECTION CRITERIA SURVEY

Respondant Number	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	Average
Ability to handle a large variety of waste	4	2	5	4	4	3	2	4	5	4	5	2	4	3.4
Automation of operation	2	1	2	4	2	5	2	3	2	3	2	2	2	2.3
Compatibility with different					5	2			3	4	3	4	5	3.0
Compatibility with big bag (or other bags)	0	2	1	5	3	5	3	4	1	2	3	4	3	2.5
Compatibility with RORO bins	1	3	1	5	4	5	3	4	1	2	4	4	3	2.8
Compatibility with standard vehicles	4	3	5	5	5	1	5	4	3	3	2	3	4	3.3
Distance it can realistically transport waste	3	3	4	3	4	4	4	4	4	3	4	4	4	3.4
Ease of setup	4	4	5	4	2	5	5	5	5	4	5	5	5	4.1
Ergonomics	4	4	5	4	3	5	5	5	4	3	4	4	5	3.8
Extraction rate	4	2	3	3	3	3	4	3	3	4	3	3	3	2.9
Freight transportation	2	2	3	5	4	5	4	3	5	4	4	5	1	3.5
Improved sanitary safety	4	3	2	4	2	4	2	4	3	3	4	3	3	2.9
Lack of civil modifications	4	5	3	3	2	4	4	3	4	3	3	5	3	3.3
Local assembly					5	5	5		5	4	4	5	4	4.1
Local maintenance	4	5	4	5	5	5	5	5	5	4	5	5	5	4.4
Local manufacturability	4	2	2	3	5	5	3	5	3	4	3	5	2	3.4
Low cost	2	2	2	5	4	4	3	5	4	4	5	5	4	3.5
Manufacturability	5	5	3	4	4	5	2	4	4	4	3	4	5	3.6
Materialization of final design	4	5		5	3	4	1	5	4	4	3	4	4	3.5
Modularity of assembly	4	2	4	4	3	5	5	4	4	4	5	4	3	3.7
No or only basic tools required for deployment	4	5	5	3	4	5	4	4	5	3	3	5	5	3.8
Off the shelf components	5	4	2	4	4	3	4	5	3	3	3	5	4	3.5
Potential to be modified for different use cases	4	4	3	2	4	3	5	4	4	3	3	5	3	3.4
Safety of the device	5	5	5	5	4	5	5	5	4	5	4	5	5	4.4
Setup time	3	5	2	2	5	3	3	4	4	3	2	4	4	3.1
Simplicity	4	5	4	4	4	4	4	5	5	4	4	5	4	4.0
Suitability for extreme rain events					1	5			3	3	4	3	2	2.7
Suitability for riverbank variation	4	5	5	5	5	3	5	4	4	3	3	4	5	3.8

APPENDIX 10: FINAL IMPORTANCE SCORE OF SELECTION CRITERIA

In order of importance:

1	Compatibility with standard vehicles	5
2	Ease of operational transportation	5
3	Ease of setup	5
4	Ergonomics during deployment	5
5	Local assembly	5
6	Local maintenance	5
7	Low cost	5
8	No or only basic tools required for deployment	5
9	Safety of the device	5
10	Setup time	5
11	Suitability for intended riverbank type	5
12	Suitability for natural riverbank variations	5
13	Feasability	5
14	Desirability	5
15	Ability to handle a large variety of waste	4
16	Lack of civil modifications	4
17	Local manufacturability	4
18	Manufacturability	4
19	Materialization of final design	4
20	Simplicity	4
21	Professional look and feel	4
22	Ability to enable pre-sorting	3
23	Compatibility with different barriers/containment systems	3
24	Compatibility with big bag (or other bags)	3
25	Compatibility with RORO bins	3
26	Distance it can realistically transport waste	3
27	Freight transportation	3
28	Improved sanitary safety	3
29	Modularity of assembly	3
30	Off the shelf components	3
31	Extraction rate	2
32	Potential to be modified for different use cases	2
33	Automation of operation	1
34	Suitability for extreme rain events	1

In alphabetical order:

22	Ability to enable pre-sorting	3
15	Ability to handle a large variety of waste	4
33	Automation of operation	1
24	Compatibility with big bag (or other bags)	3
23	Compatibility with different barriers/containment systems	3
25	Compatibility with RORO bins	3
1	Compatibility with standard vehicles	5
14	Desirability	5
26	Distance it can realistically transport waste	3
2	Ease of operational transportation	5
3	Ease of setup	5
4	Ergonomics during deployment	5
31	Extraction rate	2
13	Feasability	5
27	Freight transportation	3
28	Improved sanitary safety	3
16	Lack of civil modifications	4
5	Local assembly	5
6	Local maintenance	5
17	Local manufacturability	4
7	Low cost	5
18	Manufacturability	4
19	Materialization of final design	4
29	Modularity of assembly	3
8	No or only basic tools required for deployment	5
30	Off the shelf components	3
32	Potential to be modified for different use cases	2
21	Professional look and feel	4
9	Safety of the device	5
10	Setup time	5
20	Simplicity	4
34	Suitability for extreme rain events	1
11	Suitability for intended riverbank type	5
12	Suitability for natural riverbank variations	5

APPENDIX 11: SCENARIO MATRIX FILLED IN FOR FINAL CONCEPTSCORE OF SELECTION CRITERIA

In the matrix on the on the next two pages, the green combinations could be solved with the final design and could therefore be included in the final deployment options. Some scenarios require an add-on, like the semi-permanent stand, which allow for more versatility without compromising the design for other deployment scenarios. The orange scenarios are theoretically possible but are not included in the scope for this thesis in order to focus on the most realistic scenarios to start with.

Mobility	Distance	Angle of the shore	Container type	Reasoning	Requirements due to:			
					Mobility	Distance	Angle	Container type
Semi-permanent	Short	Steep	RORO bin		Retractable	Use without need of full chain	Support for steep angle	High support
Semi-permanent	Short	Steep	Big bag					Medium support
Semi-permanent	Short	Steep	Smaller bag/container					Low support
Semi-permanent	Short	Shallow	RORO bin				Support for shallow angle	High support
Semi-permanent	Short	Shallow	Big bag					Medium support
Semi-permanent	Short	Shallow	Smaller bag/container					Low support
Semi-permanent	Medium	Steep	RORO bin			Stackable/linkable/multiplied	Support for steep angle	High support
Semi-permanent	Medium	Steep	Big bag					Medium support
Semi-permanent	Medium	Steep	Smaller bag/container					Low support
Semi-permanent	Medium	Shallow	RORO bin				Support for shallow angle	High support
Semi-permanent	Medium	Shallow	Big bag					Medium support
Semi-permanent	Medium	Shallow	Smaller bag/container					Low support
Semi-permanent	Long	Steep	RORO bin	Hard to retract more modules with steep angle				
Semi-permanent	Long	Steep	Big bag					
Semi-permanent	Long	Steep	Smaller bag/container					
Semi-permanent	Long	Shallow	RORO bin	Possible but not focus				
Semi-permanent	Long	Shallow	Big bag					
Semi-permanent	Long	Shallow	Smaller bag/container					
Mobile	Short	Steep	RORO bin	Requires 2 trucks or attachment to transport module(s) on top of RORO bin				
Mobile	Short	Steep	Big bag		Movable	Use without need of full chain	Horizontal support	Medium support
Mobile	Short	Steep	Smaller bag/container					Low support
Mobile	Short	Shallow	RORO bin	Requires 2 trucks or attachment to transport module(s) on top of RORO bin				
Mobile	Short	Shallow	Big bag		Movable	Use without need of full chain	Variable angle support	Medium support
Mobile	Short	Shallow	Smaller bag/container					Low support
Mobile	Medium	Steep	RORO bin	Deploying two units without fixed base is top heavy and might fall in				
Mobile	Medium	Steep	Big bag					
Mobile	Medium	Steep	Smaller bag/container					
Mobile	Medium	Shallow	RORO bin	Requires 2 trucks or attachment to transport module(s) on top of RORO bin				
Mobile	Medium	Shallow	Big bag		Stackable and movable	Easily extendable/connectable second module	Variable angle support	Medium support
Mobile	Medium	Shallow	Smaller bag/container					Low support
Mobile	Long	Steep	RORO bin	Possible but not focus				
Mobile	Long	Steep	Big bag					
Mobile	Long	Steep	Smaller bag/container					
Mobile	Long	Shallow	RORO bin					
Mobile	Long	Shallow	Big bag					
Mobile	Long	Shallow	Smaller bag/container					
Permanent	Short	Steep	RORO bin	Permanent deployment requires a flood proof design which is illogical/incompatible with mobility/retractability due to the requirements about weight and extra moving (and therefore vulnerable) parts				
Permanent	Short	Steep	Big bag					
Permanent	Short	Steep	Smaller bag/container					
Permanent	Short	Shallow	RORO bin					
Permanent	Short	Shallow	Big bag					
Permanent	Short	Shallow	Smaller bag/container					
Permanent	Medium	Steep	RORO bin					
Permanent	Medium	Steep	Big bag					
Permanent	Medium	Steep	Smaller bag/container					
Permanent	Medium	Shallow	RORO bin					
Permanent	Medium	Shallow	Big bag					
Permanent	Medium	Shallow	Smaller bag/container					
Permanent	Long	Steep	RORO bin					
Permanent	Long	Steep	Big bag					
Permanent	Long	Steep	Smaller bag/container					
Permanent	Long	Shallow	RORO bin					
Permanent	Long	Shallow	Big bag					
Permanent	Long	Shallow	Smaller bag/container					

APPENDIX 12: WASTE COMPOSITION AND WEIGHT-VOLUME RATIO DEFINITION

The weight per m^3 of waste is highly dependent on the composition of set waste. If there is a lot of organic waste it is much heavier than if it mainly consists of plastics. The interceptor classics weigh their waste when dumped in the dumpsters to not overload the system. The limit each dumpster can hold has to be monitored and altered in the first weeks of use in a certain area since volume can also be the limiting factor of the system. The top conveyor should not be able to hit the waste when moving over the dumpsters. So for areas with a lot of light but voluminous objects this maximum weight per dumpster needs to be adjusted. In the interceptor 2.0, the barge with containers has a total volume of 42m3 and is filled up to about 38m^3. This 38m^3 weighs around 6,75 metric tonnes resulting in an average weight of 178kg/m^3. (Personal communication, 2023) However, when the waste would consist of only PET bottles filled with air it would weigh around 30-35kg/m^3. This is never the case since about 40% of the PET bottles extracted are partially filled with mud or other dirty substances making them ineligible for recycling (Personal communication, 2023). Next to that, there is a lot of different kinds of waste mixed. When operators are present and able to separate part of the natural organic waste from the other waste before it gets extracted the weight per cubic meter would go down but for this design case, the weight that needs to be extracted is estimated to be between 100 and 200kg/m^3. When designing an extraction mechanism, the design should be able to handle the worst case which is the heaviest load of 200kg/m^3.

Sungai watch operates in rivers where a mobile extraction technology could be useful. It is stated in their 2022 impact report (source) that their barriers catch 2 to 200kg of non-organic waste per day. This is dry waste but the waste that needs to be extracted is wet. At the Interceptor 004 in the Dominican Republic for example, the wet weight of the extracted waste is 10 times the weight of the dry plastic waste after sorting (Personal communication, 2023). With this in mind, in a use case like Sungai Watch, the total weight of wet waste can vary between 20 to 2.000kg per day.

The first criteria to look at if a river site could benefit from a modular extraction mechanism is the amount of waste that flows by. A site with a large amount of waste (>5.000kg per day) would benefit from daily clean-up or even 24/7 extraction. In this case it might be worth the time and money to install a permanent extraction mechanism that is designed for that specific site. For sites with a small amount of waste flowing through (<500kg per day), manual clean-up will be advantageous to placing mechanical extraction mechanisms. In this case the cost of the machine or the time to set it up would not be worth the possible impact. It would be cheaper and easier to buy good quality protective gear and clean it manually. The sites with a medium amount of waste (500-5.000kg a day) could benefit from a mobile extraction mechanism. Since the interval of extraction can be based on the amount of waste, all these sites can be serviced when between 5.000 and 20.000kg has accumulated.

5.000kg of waste with a weight of 150kg/m^3 is approximately 33m^3. Since the waste is spread out over the surface of the water it can also be expressed in m^2 with a height of 15cm. 15cm is taken as an average height of the floating waste since some objects create a floating layer of 10cm thick while other objects are 20cm high. There is an occasional polystyrene box of 50cm high but overall 15cm would be a good estimate. This 5.000kg of waste would accumulate to a waste patch of around 220m^2. 20.000kg of waste would float on the water as a patch of around 900m^2.

APPENDIX 13: FRAME CONSTRUCTION COMPARISON

Appendix 13: Frame construction comparison

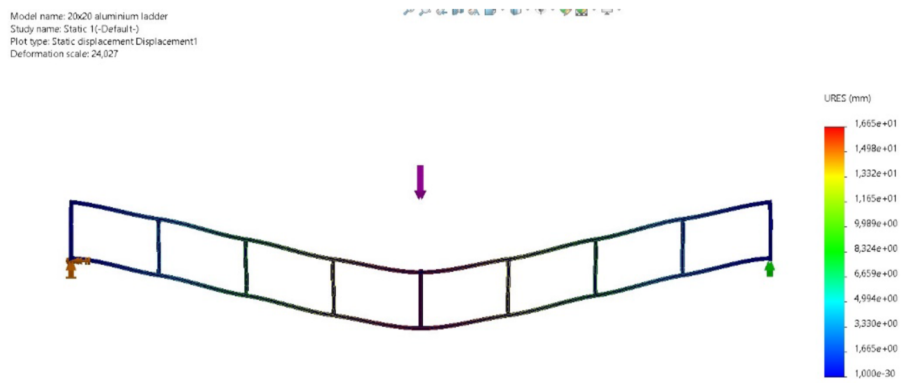
Sides and bottom from one plate of sheet metal with tubes around the edges for reinforcement
After making a representative SolidWorks model, it quickly became apparent that this construction becomes very heavy in order to get the required stiffness, therefore it was eliminated.

Two ladder trusses with welded connection braces in the middle and bottom
In order to get the required stiffness and height for the whole belt including flights with off the shelf components, a ladder truss seemed like a good solution. It was expected to be cheaper than welding something from scratch, however a 4m long ladder truss generally costs somewhere between the 180 and 300 euro. The cheapest found was €155 excl. BTW while the materials on its own cost around the €100 excl. BTW. Depending on where it is manufactured, the welding costs would make the difference. Since off the shelf trusses need to be modified with all the cross braces, axis mounting plates, and accessories, it seems to make a minimal difference. Thus making a completely custom frame would be similar in price but allows for extra design freedom.

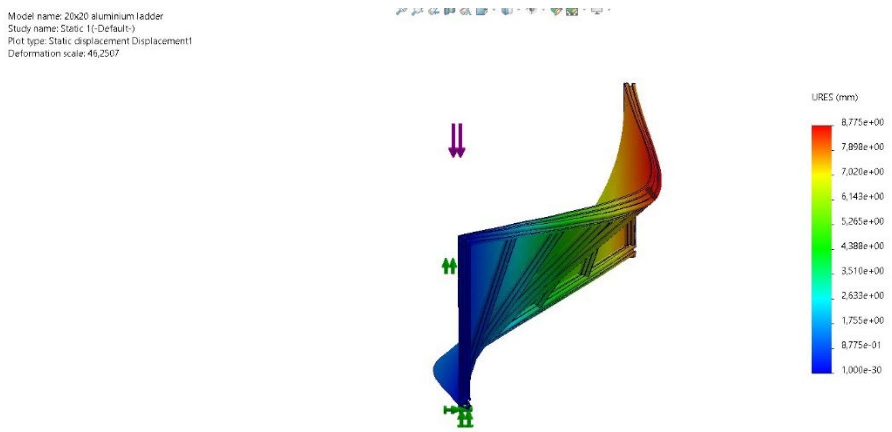
Aluminium construction profiles connected with angle brackets
These aluminium extrusion profiles are available in several different standardized sizes. Through an iterative process of *Finite Element Analyses in SolidWorks, each type of profile* was *analysed in order to find a balance between cost, strength, and weight.*

A snippet of this iterative process is added below.

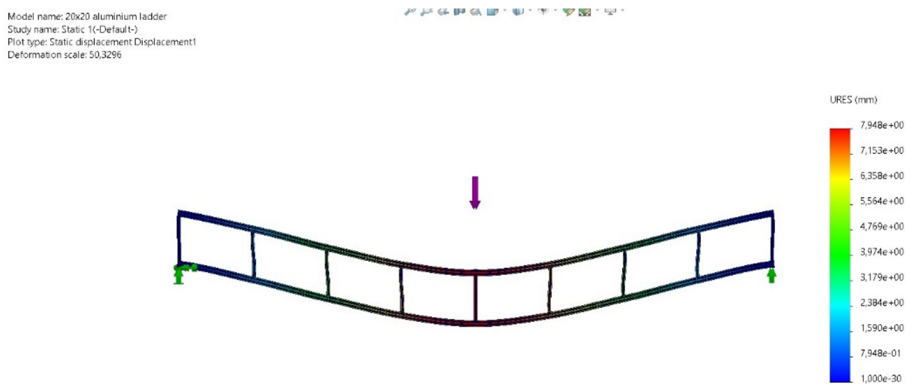
Starting at 20x20 profiles different constructions were tested in order to find one that is as light as possible while being strong enough to carry multiple trash bags of 30kg. Even with 9 vertical standers and just one trash bag in the middle, the deflection is 17mm.



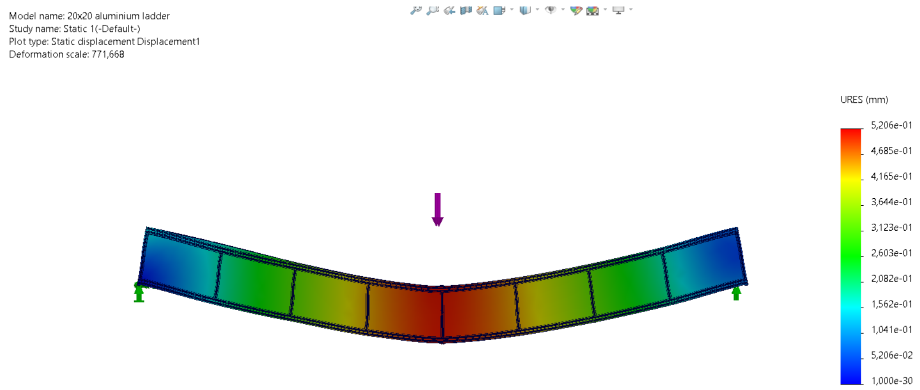
Adding a PP plate of 2mm thick adds vertical rigidity but buckles sideways to a total distance of 8.8mm as can be seen in the following figure.



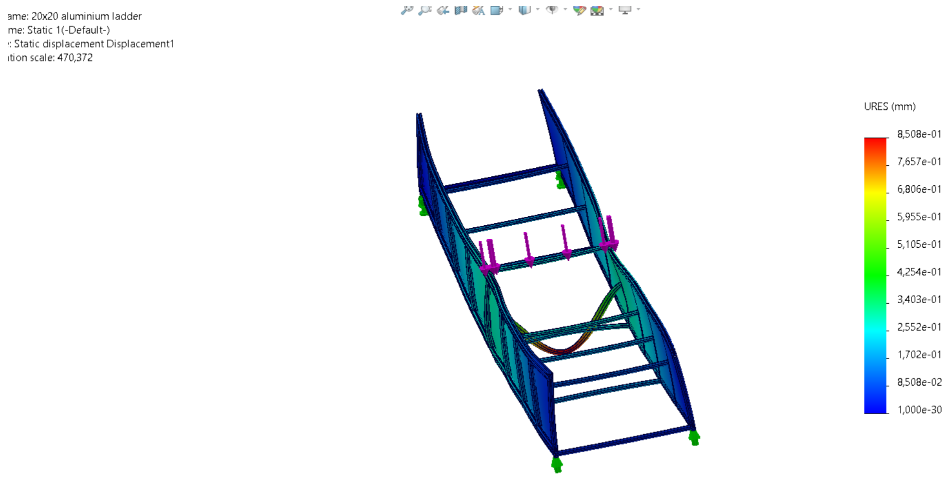
Doubling the top and bottom stretcher would almost double the weight (from 4.6kg to 8kg) while still deflecting 7.9mm as can be seen in the next figure.



By adding the 2mm PE plate again, the displacement is deflected sideways with a maximum of 2,2mm. By adding bracing between the two sides, the outwards deflection is minimized to 0,5mm as can be seen below.

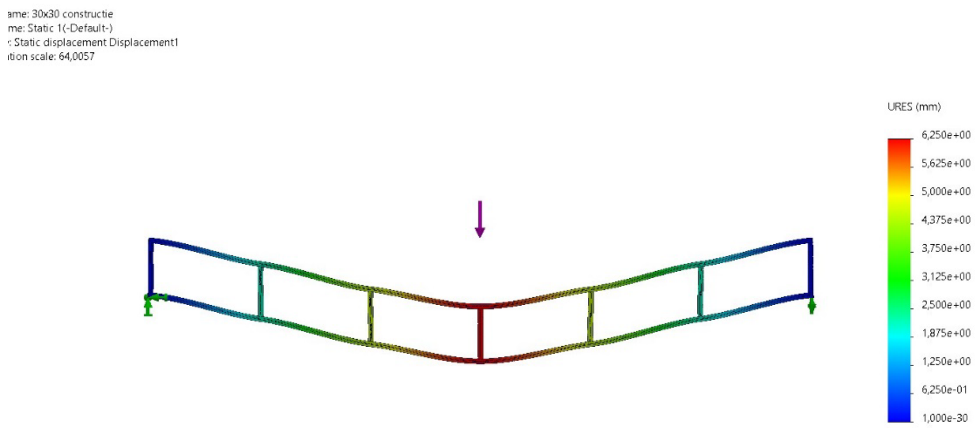


Depending on the type of belt it will be supported by a fully closed plate, rollers, or sliding strips. The closed plate and sliding strips would be supported by the cross braces. A more realistic scenario would be a force distributed over one of the braces since they support the belt. By placing a force of 350N on the centre cross brace (50N is added due to the weight of the belt itself) the displacement is as follows:



centre cross brace displaces 0,9mm and the rest of the construction displaces 0,6mm or less. vever, when it is exposed to sideways forces, the frame buckles 1.5mm inwards.

:e this is still with the minimum weight scenario of one trash bag, it was chosen to explore one › up, 30x30 aluminium profiles. In this case, when the same test is executed as the initial test for 20x20 profiles and 300N is placed in the middle vertically down, the displacement is 6.3mm ead of the 17 of the 20x20 profiles.



ısing a 30×60 profile at the top and bottom, the displacement is reduced to 3mm. However the ght increases up to a point where it's comparable with the 40×40 structure. Each side becomes when 7 vertical profiles are used. The complete structure with 7 vertical profiles per side and 10 ;s braces weighs 33kg. While the 40×40 structure is 12.4kg per side with 5 vertical profiles just 5 ;s braces have to be added to create a stiffer structure resulting in 28.7kg in total.

ıis manner, a lot of different options were tested against each other. Also with triangles at the ;s for example. In that case the decision has to be made if the inconvenience of having angles in design, which propagate throughout the whole structure, is worth the extra stiffness. Especially ı aluminium construction profiles, it will affect all the cross braces and therefore belt support e the profiles can only be connected in one way with the available brackets.

se considerations were done until the 40x40 profiles were chosen in a ladder fashion as can also ;een in the final design. It could handle more force than required but for such a prototype, it's :er to go too strong than too weak, which seems to be a good decision since the overall weight t increasing during the process, resulting in the need for an extra strong structure.

APPENDIX 14: BELT TYPES COMPARISON

Plastic linked conveyor

fablink-md25.4PR^%48 → Weight: 4,2kg/m² → 4m long (about 8,5 back and forth) and 60cm wide ≈ 5,1m² ≈ 21kg

Ashworth prestoflex 55% open → Weight: 3,27kg/m² → 4m long (about 8,5 back and forth) and 60cm wide ≈ 5,1m² ≈ 16,67kg

FabLink-EC25.4.PR%16: 5,1×4,7≈24kg
FabLink-MD50.8.FG: 5,1×7,2≈36,7kg

Advice on specific belt type is required to make a proper dicision. There are reasonably light versions, but are they strong enough.

Pros and cons

- \+ Allows water to flow through
- \+ Low maintenance
- \+ Easy repair
- \+ Modularity with attachments like flights
- \+ Misalignment is less of a problem
- – Weight
- – Strength (dependant on the belt stype)
- – Clogging (sides need tob e property closed off to prevent clogging)

Metal mesh conveyor

Weight: 6,98 kg/m at a width of 813mm → ± 59,3kg (8,5×6,98) for a full 4 meter long conveyor of Ashworths omni-flex belt

Pros and cons

- \+ Strength
- \+ Modularity with attachments like flights
- – **WEIGHT**
- – Not easy to repair
- – Price
- – Clogging same issue as modular plastic belt

Rubber conveyor

Pros and cons

- – Does not allow for drainage
- – Stops water flow
- – Misalignment or dirt build up causes belt to drift and wear down fast
- – One piece means once it gets damaged, the whole belt needs to be replaced

Fabric conveyor

PE, PU, PVC, or silicone, coated belts.

Different types of layered or coated materials to reach certain requirements.

Pros and cons

- \+ Allows for drainage with laser cut holes (this reduces the strength and stability and increases the price)
- – Stops water flow if no holes are cut
- – Misalignment or dirt build up causes belt to drift and wear down fast
- – One piece means once it gets damaged, the whole belt needs to be replaced

Gauze belt

Pros and cons

- \+ Allows for drainage
- \+ Allows for water to flow through
- \+ Weight
- – Strength
- – No repairability options

Initial belt requirements

- Waterproof
- UV-resistant
- Water permeable?
- ±60 cm wide 4 meters long
- Can carry 30kg on a 40×40cm surface (so should be able to carry 300 kg spread out over the whole belt)
- Can transport large variety of waste including branches (puncture resistance)
- Does not add a lot of weight
- Price reasonable for added value
- Repairable or cheap to replace

Taking all the information and advise from experts into account, the modular plastic link belt seemed like an interesting idea to test.

APPENDIX 15: MOTOR POWER CALCULATIONS

RPM motor

The sprocket has a diameter of 107.37mm and the belt modules are 16mm thick. This means that if we want to calculate the speed of the top of the belt, we have to calculate with a radius of $\frac{107.37}{2} + 16 = 69.7mm$.
A full rotation of the motor would mean that the belt moves 0.438m ($69.7 * 2\pi$). For the speed of 0.1m/s as stated in the requirements, the motor should turn at approximately $\frac{0.1*60}{0.438} = 13.7RPM$.

This speed is chosen to be the same as used on the Interceptor Original to allow for water drainage during transportation. Ideally the motor can be set to different speeds from **10 up to 50** RPM (or even up to 100RPM) in order to test different speeds. This would result in a belt speed of 0.1m/s to 0.3m/s.

Maximum normal force

If 4 trash bags of 30kg are simultaneously transported the total weight will be 120kg. If the conveyor is used at its minimal angle of 10° the normal force is calculated as follows:
$Fn = m * g * \cos(\alpha)$

$120 * 9.81 * \cos(10) = 1.159\text{N}$

Tensile stress

The situation where most force is exerted on the belt instead of the cross braces is with the maximum angle of 50°. At this situation the tensile strength of the belt is of importance. If these same 4 bags are placed on the conveyor, the total force - the normal force is pulling on the belt.

$120 * 9.81 - 120 * 9.81 * \cos(50) = 1{,}177 - 756 = 421N$

In case a bag rolls over a flight and lands on the next one, we can assume it falls over a distance of 0.5m. If the deformation distance of the bag is 10cm and the flight deflects about 2cm while absorbing the force, the average force exerted on the belt during the crash can be calculated as follows:

$$F_{avg} = \frac{m * g * h}{d}$$

$$\frac{30 * 9.81 * 0.5}{0.12} = 1{,}226N$$

In the static scenario, about 60% of the force is absorbed by the cross braces as can be seen in the calculations earlier. If the same can be said about falling objects, the tensile stress on the belt is in this scenario $1{,}226 * 0.4 = 491N$.

If both scenarios are combined the total tensile strength of the belt should be above $421 + 491 = 912N$.

Torque

For the torque we combine the force with the radius of the sprocket. For the maximum torque we have to assume all the force is placed on the ends of the flights increasing this radius with 50mm.

As first estimation, 912N can be taken as maximum force against the direction of the motor rotation due to gravitational pull. Due to friction between the belt and the support strips, a total force of around 1,000N can be estimated. With an arm of 0.0697m, this results in a torque of 69.7Nm (since τ=r×F).

A motor that can handle a torque of **80Nm** should be able to handle all situations in a realistic use scenario.

These calculations are compared with the results of a belt conveyor motor sizing tool from Oriental Motor which can be found in Appendix 25. The results are relatively close with a torque of 76Nm. However with an added safety factor of 1.5 it becomes 114Nm.

For the proof of principle prototype a motor rated for 80Nm is used since this was readily available. However, in the case of further development or production, a motor that can handle more is advised.

Required motor power

Belt length $= \mathbf{4.0m}$
Radius sprocket $+$ belt thickness $= \mathbf{69.7mm}$ (see RPM calculations)
Total length $= 2 \times 4 + 69.7 * 2\pi = \mathbf{8.4m}$
Belt width $= \mathbf{0.6m}$
Belt density $= \mathbf{8.4kg/m^2}$
Belt weight $= Total\ length * Belt\ width * Belt\ density = 8.4 * 0.6 * 8.4 = \mathbf{42.3kg}$
Load weight $= \mathbf{120.0kg}$
Total weight $= load\ weight + belt\ weight = 120.0 + 42.3 = \mathbf{162.3kg}$
Friction coefficient PE $-$ Alu $= \mathbf{0.2}$
Required belt pull $= Total\ weight + Friction\ coefficient = 162.3 * 0.2 = \mathbf{32.5kg}$
Linear speed $= 0.1m/s = \mathbf{6.0m/min}$
Height $= Belt\ length * \sin(\alpha) = 4 \times sin(50) = \mathbf{3.06m}$
Gravity pull $= Total\ weight/Belt\ length * Height = 162.3/4.0 * 3.06 = \mathbf{124.2kg}$
Total pull $= Required\ belt\ pull + Gravity\ pull = 32.5 + 124.2 = \mathbf{156.7kg}$
Required power $= Total\ pull * Linear\ speed = 156.7 * 6.0 = \mathbf{940.2kg * m/min}$
Required power in Watts $= Required\ power/60 = \mathbf{15.7W}$

APPENDIX 16: BUOYANCY FORCE CALCULATIONS

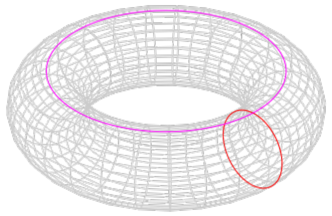
Wheels

Beach wheels

To calculate the buoyancy of wheels, the volume of air that is contained in these wheels needs to be calculated. Wheels can be simplified to either a flat cylinder with a cylindrical cut-out in the centre or a torus.

The beach wheels (as shown on the right) closely resemble the shape of a torus, so for these calculations the following equation can be used.

$$V = 2 * \pi^2 * r^2 * R$$

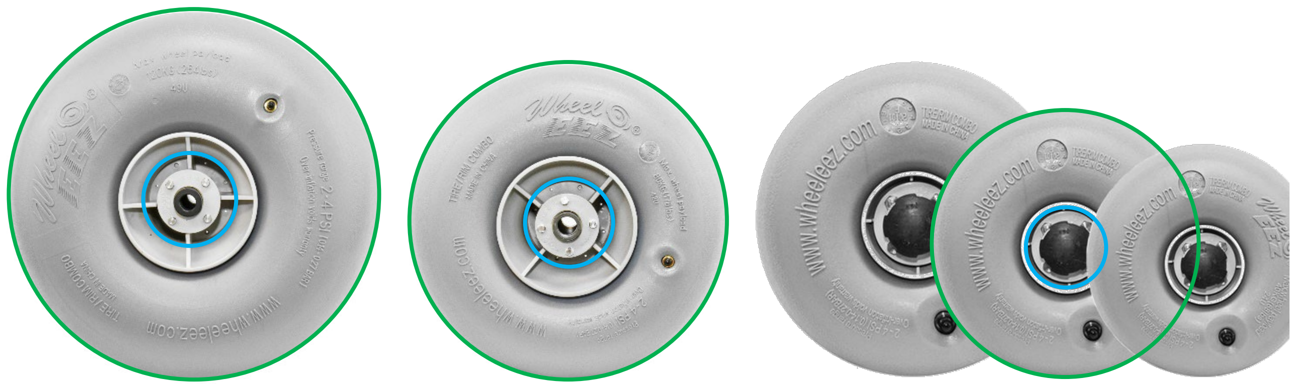


V = volume
r = radius of the red circle
R = radius of the pink circle

This can be rewritten to an equation that is dependent on the inner radius (R_i) and outer radius (R_o) of the torus:

$$V = 2 * \pi^2 * (R_o - R_i)^2 * \left(\frac{(R_o - R_i)}{2} + R_i\right)$$

Two possible sizes of beach wheels are 42 and 49 cm in diameter. The inner diameter is estimated with the following pictures. Since these pictures are not taken perfectly straight on from the centre and there is most likely camera distortion, it's a rough estimate. However, it gives an indication for the buoyancy. The figures are shown on 1/10 scale where the outer diameters (green) are 4.2 and 4.9 cm. The inner diameters (blue) are 1.23 and 1.17. It is not unlikely that the wheels are produced with the same inner diameter, resulting in an average of 12cm In full scale.



Using these measurements as input for the equation the volume of the 49cm wheel is approximately $0.026m^3$ and the volume of the 42cm wheel is around $0.015m^3$.

The buoyant force can be calculated with the following equation:

$$B = \rho * V * g$$

B = buoyant force
ρ = density of the liquid
V = volume of displaced liquid
g = gravitational acceleration

Water has a density of approximately $1kg/m^3$. Since the river water will not be pure water, it will be slightly heavier (sea water for example has a density around 1.025kg/m3). For these calculations $1kg/m^3$ will be precise enough. For the gravitational acceleration 9.81 is used.

When the complete wheels are submerged, the buoyant force will be 255N for the 49cm wheel and 147N for the 42cm wheel. Since the conveyor will have two wheels, with the 49cm wheels, the maximum total weight is around 52kg. With the 42cm wheels it is 30kg.

Wheelbarrow wheels

In contrast to beach wheels, large wheelbarrow wheels are 40cm in diameter and 10cm wide. In this case, the torus shaped inner tube has a volume of around $0.0074m^3$ which results in a buoyant force of 73N. This would mean that with two wheels, the maximum total weight of the conveyor is approximately 15kg. However, these wheels are widely available around the world and cost around €20 per tire. For that reason it is better to double up these wheels than choose for the 42cm beach wheel. When two are mounted on each side of the conveyor, the maximum total weight of the conveyor would be 30kg, just like the 42cm beach wheels.

Extra floaters

Polystyrene blocks

Blocks of polystyrene can be added between the frame to make it more buoyant. If a 80×30×4cm block is added on either side, it adds a buoyancy force of 188N resulting in a max total volume of 19kg extra.

Fenders

Inflatable

If buoys /fenders are added on the sides instead (cylinders with a diameter of 15cm and a length of 50cm filled with air), it would result in an extra buoyancy force of 693N resulting in a max total weight of 70kg extra. Having two on each side would result in a maximum total weight of 140kg. Since the conveyor is also supported on the shore, this should be enough during operation.

Smaller fenders of 12cm and a height of around 35cm would allow for a maximum weight of 15kg per fender. Four of these fenders can keep 60kg afloat.

Foam

Flat foam fenders can be used for a cleaner look. A block of 65×24×8cm is 767 gram, meaning it has a density of approximately $61.5kg/m^3$. According to Archimedes' principle, this would add a buoyant force of 122N per plate. With four of these plates in total, it can keep around 48kg afloat which is not enough. Even after adding 8, it's enough for the belt alone, but it might dip under too much when waste is extracted.

APPENDIX 17: MATERIAL AND PRICE LIST OF FINAL PROTOTYPE

Name	Discription	Amount	Link	Price	Total price
Base model without legs or stand					€ 3,296.76
40x40 construction profiles pre-cut	Length of 4000mm	4	https://www.aluxprofiel.nl/aluminium-co	€ 63.96	€ 255.84
40x40 construction profiles full-length	Max length of 6030mm (cut to 10x350mm, 5x610mm, 5x522mm)	2	https://www.aluxprofiel.nl/aluminium-co	€ 96.42	€ 192.84
Linear slider 4040	No fasteners	4	https://www.aluxprofiel.nl/lineair-geleide	€ 7.99	€ 31.96
T-nut insert joiners	T-slot 8, M8	100	https://www.aluxprofiel.nl/inklikmoer-40	€ 0.22	€ 22.00
T-nut slide joiners	T-slot 8, M8	300	https://www.aluxprofiel.nl/inschuifmoer-	€ 0.26	€ 78.00
Screws	M8x16 (sold per 200)	400	https://www.fabory.com/nl/laagbolkopsc	€ 0.13	€ 50.40
Corner bracket 4040	No fasteners, no cover	100	https://www.aluxprofiel.nl/verbindingsho	€ 0.75	€ 75.00
Recycled PE protection plates	Max size of 2000x1000mm	2	https://www.s-polytec.nl/pehd-regenera	€ 55.12	€ 110.24
Belt with flights and sprockets	600mm wide and 9,144mm long with 12 flights	1	https://www.bandtransporteurope.nl/tra	€ 1,412.74	€ 1,412.74
Motor	40W, 24V DC, 80Nm, 25RPM geared motor	1	https://nl.rs-online.com/web/p/dc-motor	€ 402.63	€ 402.63
Motor controler	9-60V PWM switch	1	https://www.amazon.nl/dp/B08BYTHWRI	€ 14.49	€ 14.49
Battery	24V (Ah can be chosen based on use scenario)	1	https://www.amazon.nl/dp/B08ZD3SNWI	€ 63.63	€ 63.63
Waterproof wire connectors	2 required but comes in set of 10	1	https://www.amazon.nl/dp/B0BWJ6W87	€ 6.31	€ 6.31
Waterproof bearings	NG F4 (1x open and 3x closed)	4	https://shop.dielemantt.nl/280-ng-lagers	€ 56.80	€ 227.20
Wheels	Wheelbarrow wheels (d=400mm)	2	https://wielencentrale.nl/product/skelter	€ 13.85	€ 27.69
U profiles for belt suport	40x40 U profile, 4000mm long	3	https://www.aluminiumshop.nl/aluminiur	€ 46.19	€ 138.57
L profiles for belt suport	50x20x2mm L profile, 4000mm long	4	https://www.aluminiumshop.nl/aluminiur	€ 18.97	€ 75.88
Aluminium 30mm rod	2500mm (1x upper axis 736mm, 1x lower axis 686mm, 4x handles with internal thread 100 mm, 2x handles with external thread 112mm, 2x suports 150mm)	1	https://www.aluminiumshop.nl/aluminiur	€ 59.42	€ 59.42
Wheelbarrow handle set	Amount can be increased when more handles are prefered	3	https://toolscentrale.nl/product/tuin/trar	€ 2.84	€ 8.53
Aluminium 20mm rod	800mm (4x upper fender connector 80mm, 4x lower fender connector 120mm)	1	https://www.aluminiumshop.nl/aluminiur	€ 9.30	€ 9.30
Fenders	12x45cm	4	https://www.georgekniest.nl/artikel/2566	€ 8.52	€ 34.08
Linkable sliders					€ 72.54
Linear slider 4040	No fasteners	4	https://www.aluxprofiel.nl/lineair-geleide	€ 7.99	€ 31.96
Lap joint connector	No fasteners	2	https://www.aluxprofiel.nl/draaihoek-40-	€ 5.99	€ 11.98
Excentric hinge handle	Order number: K0646.1531106 (X=M6 internal threading)	4	https://www.kippcom.nl/nl/nl/Producten/	€ 7.15	€ 28.60
Extendable V-shaped legs					€ 225.92
40x40 construction profiles full-length	Length of 4500mm (cut to 4x120mm, 4x1000mm)	1	https://www.aluxprofiel.nl/aluminium-co	€ 71.96	€ 71.96
Hinge connector 4040	No fasteners	6	https://www.aluxprofiel.nl/scharnierverbi	€ 9.99	€ 59.94
Hinge handle	Order number: K0123.1061X15 (X=M6 and L=15)	2	https://www.kippcom.nl/nl/nl/Producten/	€ 6.40	€ 12.80
Excentric hinge handle	Order number: K0646.1531106 (X=M6 internal threading)	4	https://www.kippcom.nl/nl/nl/Producten/	€ 7.15	€ 28.60
Square tube	AxAxD=45x45x2, L=2000	1	https://ijzershop.nl/vierkante-koker/1235	€ 18.42	€ 18.42
Extra wheels	Smaller wheelbarrow wheels (d=260mm)	2	https://wielencentrale.nl/product/steekw	€ 10.33	€ 20.66
Wheel locks	Horizontal toggle clamp	2	https://www.amazon.nl/dp/B096YV2J9C?	€ 6.77	€ 13.54
Semi-permanent stand					€ 231.16
40x40 construction profiles full-length	Max length of 6030mm	2	https://www.aluxprofiel.nl/aluminium-co	€ 96.42	€ 192.84
45 degrees profile connector	No fasteners	6	https://www.aluxprofiel.nl/profielverbind	€ 3.39	€ 20.34
Lap joint connector	No fasteners	2	https://www.aluxprofiel.nl/draaihoek-40-	€ 5.99	€ 11.98
Corner bracket 4040	No fasteners, no cover	8	https://www.aluxprofiel.nl/verbindingsho	€ 0.75	€ 6.00
Total price					€ 4,124.84

APPENDIX 18: ORIGINAL PROJECT BRIEF

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

Your master programme (only select the options that apply to you):

IDE master(s): ★ IPD ◯ Dfl ◯ SPD

2[nd] non-IDE master:

individual programme: - - (give date of approval)

honours programme: ◯ Honours Programme Master

specialisation / annotation: ◯ Medisign

◯ Tech. in Sustainable Design

◯ Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair	Jan Carel Diehl	dept. / section:	SDE/DfS
** mentor	Wim Schermer	dept. / section:	HCD/DA
2[nd] mentor	Jasper van Eijk		
organisation:	The Ocean Cleanup		
city:	Rotterdam	country:	The Netherlands

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

TU Delft

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Jan Carel Diehl date 20 - 11 - 2022 signature Jan-Carel Diehl Digitally signed by Jan-Carel Diehl Date: 2022.11.20 18:01:26 +01'00'

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 42 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 30 EC

List of electives obtained before the third semester without approval of the BoE

★ YES all 1[st] year master courses passed

◯ NO missing 1[st] year master courses are:

name C. van der Bunt date 02 - 12 - 2022 signature C. van der Bunt Digitally signed by C. van der Bunt Date: 2022.12.02 12:07:40 +01'00'

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ★ APPROVED ◯ NOT APPROVED

Procedure: ★ APPROVED ◯ NOT APPROVED

comments

name Monique von Morgen date 13 - 12 - 2022 signature

Initials & Name J.S. van Stijn 6046 Student number 4550560

Title of Project Design of a direct-to-shore modular extractor of plastic from rivers

Design of a direct-to-shore modular extractor of plastic from rivers — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 07 - 11 - 2022 — 22 - 05 - 2023 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

The ocean is polluted with a large quantity of plastic waste, resulting in a negative impact on people and planet in the short and long term. Most of this plastic gets into the ocean by the means of rivers that flow through highly polluted areas around the world. The Ocean Cleanup aims to get the ocean plastic free again by actively removing it from the ocean and by filtering it out of the rivers before it flows into the ocean.

One of the technologies that The Ocean Cleanup uses for this is the Interceptor Original; a solution that filters and extracts the plastic in the middle of a river where the containers are picked up and brought to the shore by smaller boats. This offloading method is highly dependent on the tides, meaning that the Interceptor Original can only be offloaded on specific moments which greatly reduces the overall collecting capacity. Besides the limitations of the offloading method, the current Interceptor Original can only collect on certain large rivers that are accessible via the water from a harbour nearby.
Another technology from The Ocean Cleanup is called the Interceptor Tender, which is a human controlled boat with which they can collect trash from behind a barrier at the mouth of smaller rivers or gullies and offload at the harbour. This leaves the opportunity for a technology in smaller rivers that can transport the trash directly onto the shore where it can be taken away. Reducing the need for a harbour nearby since there are no boats needed to pick up the trash. If it can be lowered in the river from the shore it can be used in locations where access from the sea is limited by low bridges, shallow areas, or height differences. Besides that, it allows for less downtime in between offloads, increasing efficiency.

The Ocean Cleanup has developed two solution spaces in cooperation with Spark Design and Innovation where they want to move forward with. One is similar to solutions other companies use, with a long rigid conveyor belt which works well in certain situations. The other one, which is used as starting point for this project, is the idea of segmented conveyor belts that can be connected to whatever length needed and lowered into the water from the shore. These segments can float on the water or lay on dry land, giving it a lot of versatility and flexibility with tides.

The main stakeholder for this project is The Ocean Cleanup. However, since Spark Design and Innovation will eventually be working on the other solution, so it might be interesting to also stay in contact with them in order to make the most impact with these two new technologies. Other stakeholders to keep in mind are collaborative organisations, manufacturers, local municipalities, and residents of the neighbourhoods where the design could be deployed. For example, since The Ocean Cleanup is a non-profit foundation, the technology should not only work but also attract some positive attention. Attention to get more funding, but also to show the world that structural changes need to be made. Getting this attention should however not make it intrusive for the residents that live nearby.

As with a lot of The Ocean Cleanup's projects, it is easier to get local cooperation and permits if it is advertised as a temporary installation. This means that the design should be for example anchored down with a system that is minimal invasive. The system itself should be designed to function under harsh conditions like high forces and salt or even toxic water. However, the weight should also be taken into account in order to make the user scenario as pleasant as possible when it is deployed or while in use. Next to all these considerations, environmental impact of the materials, manufacturability, and recyclability should be taken into account. The aim of the project is creating an integral design by finding a balance between the factors mentioned above and more.

space available for images / figures on next page

introduction (continued): space for images

image / figure 1: Current extraction and containment solutions for rivers from The Ocean Cleanup

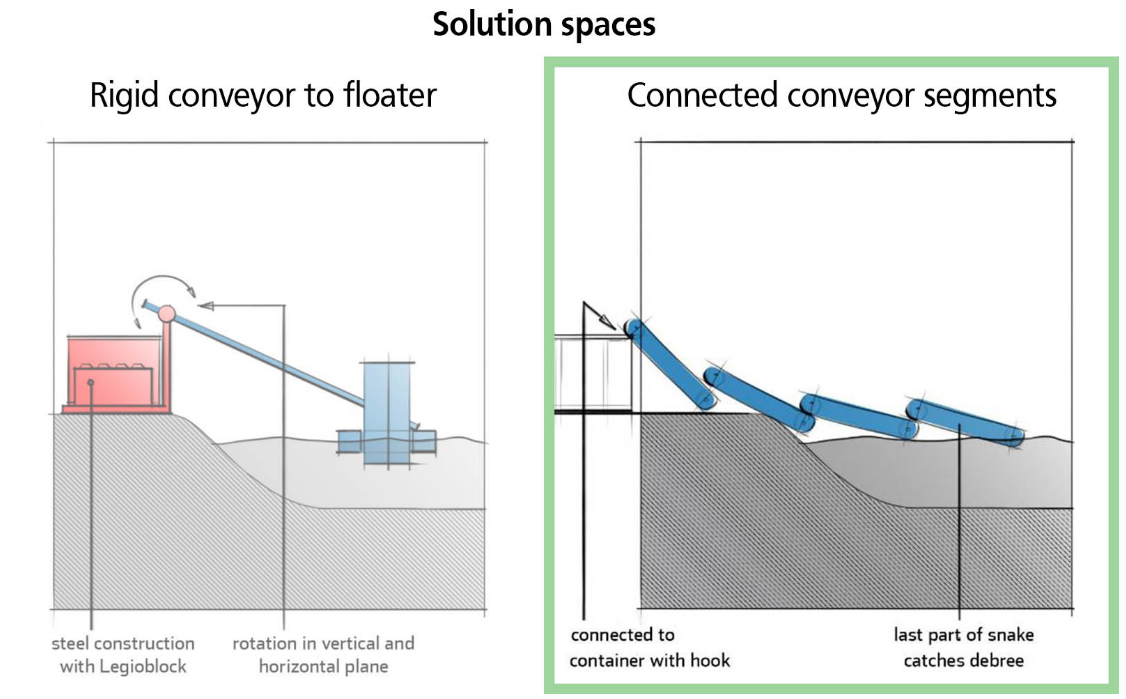


image / figure 2: Two new solution spaces for The Ocean Cleanup's portfolio (the right one is the focus of this project)

Personal Project Brief - IDE Master Graduation

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

In the introduction, the limitations of the current solutions have been discussed. During the project I will be focusing on designing a system that can fill this gap in the market and The Ocean cleanup's portfolio of River solutions; a solution for smaller hard to access rivers, to extract trash from the water and offload onto the shore.

The scope of the project will be designing the conveyor-belt elements for rivers with a natural riverbank with a slope up to 50 degrees. Quaysides (high vertical shores) are not within the scope of this project since there are already solutions out there that seem to be a better fit. Containment of the trash before extraction can be done with different types of barriers, upstream or downstream, but this project focuses on extraction itself from the place that the plastic is already concentrated in the water.

Research on potential locations where it could be deployed will be done to get knowledge about the possible use cycle of the design including setting up, extracting plastic in different scenarios, and repairing/removing the device. The research about setting up or removing the device and the infrastructure after the plastic gets on the shore will be limited. For example, how wires or barriers should be pre-tensioned can be made into a whole research on its own and differs per deployment location. For this project, it will be taken into account to make sure the concept is plausible but the final development and testing of details can be done once the proof of principle seems to have enough potential. Besides the contextual and technological research, the goal is to design an extraction intervention and make a prototype to test with.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Design a proof of principle for a small direct-to-shore plastic extraction solution while keeping usability of the design, technical transportation solutions, stability, and efficiency with currents and tides in mind.

The ideation will focus on the conveyor-belt system, floaters, and anchoring method, after which concepts will be made to execute tests based on factors like function, usability, or manufacturability. After working out the final concept, a proof of principle prototype will be made to test in scale or full size. The research and proof of principle design will show if such a solution is feasible in the context of small rivers with parameters like natural/slow rising shore lines.

Initials & Name J.S. van Stijn 6046 Student number 4550560

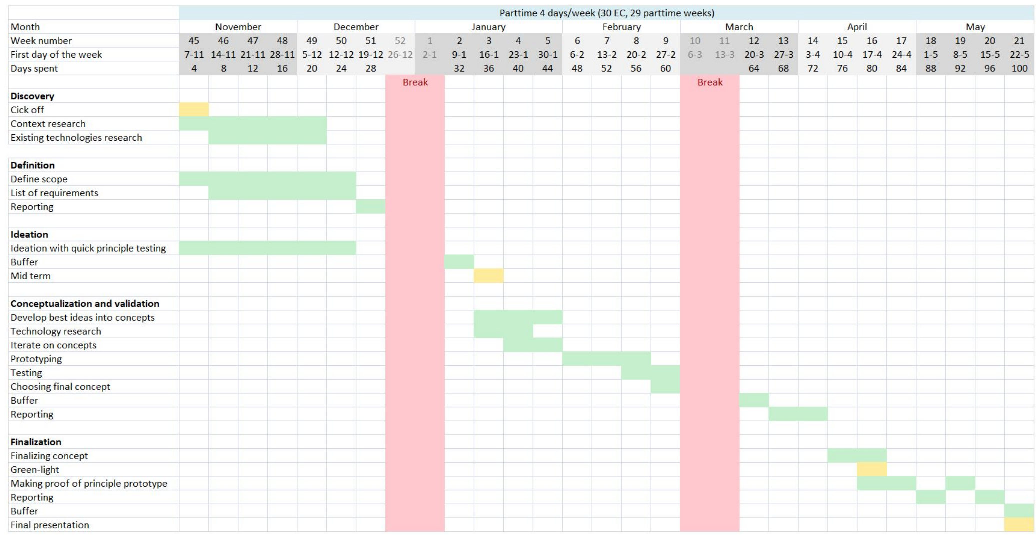
Title of Project Design of a direct-to-shore modular extractor of plastic from rivers

Personal Project Brief - IDE Master Graduation

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 7 - 11 - 2022 22 - 5 - 2023 end date



I will be working on the project for four days a week in order to work as student assistant on the fifth day. I split up the project in several phases. I will be diverging in the discovery phase, converging in the Definition phase, diverging again during the ideation phase, and converging in the conceptualization and validation phase. I end with the finalization phase to finalize the design and the prototype, finish the report, and prepare for the final presentation.
I planned several reporting weeks spread out over the course of the project and three buffer weeks for if something takes longer than expected.

Initials & Name J.S. van Stijn 6046 Student number 4550560

Title of Project Design of a direct-to-shore modular extractor of plastic from rivers

Personal Project Brief - IDE Master Graduation

TU Delft

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

My goal was to find a graduation project with which I can create something meaningful. The Ocean Cleanup is the perfect company to achieve this. I believe that the project is perfectly suited for a graduation project because I can showcase a lot of skills I have learned during my studies. The final goal is an integral design to show a brief but comprehensive overview of all these skills. Ending with a physical prototype gives me the opportunity to further develop and show my existing prototyping abilities.

Besides showing what I have already learned, I would like to further develop a structured working method. Including reporting, planning and managing project stakeholders. I expect this to be the main hurdle in such a large individual project. Besides that, I have the tendency to overdo things, focus too much on the details, ignore signs of exhaustion and just keep going in order to get the best result. So, that would also be a reason to prioritize the work and stick to the schedule as much as possible. Not only the global schedule, but also stick to the daily allocated hours, keeping mental health in mind.

Part of the structured working method entails keeping up with reporting. With a project this size, you can't wait with writing the report until the end. This is why I allocated one week after the discovery and definition phase and two weeks before the green light meeting to reporting. At the end of the project I also have two weeks to finalize everything and make the presentation next to the weeks I can spend on making the final prototype as showcase.

Lastly I would like to improve my skills in making quick but commutative visuals to use in conversations with my supervisory team or other stakeholders. These visuals can be digital sketches, but also the 3D files should be structured and parametric to allow for quick changes.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

APPENDIX 19: COMPLETE LIST OF COMPILED SITE CHARACTERISTICS

With special thanks to Hidde Coehoorn for leading the brainstorm session and compiling everyone's input into the final list of river site characteristics.

	River site characteristics	Range	Relevant to: Containment system (19)	Relevant to: Extraction system (25)
1	River width	Wide/narrow	✓	
2	River traffic	None/busy	✓	
3	River shape	Straight/winding	✓	
4	Land ownership	State/private	✓	✓
5	Exposure to public opinion	Out of sight/ city centre	✓	✓
6	Accessibility by land	Not at all/fully	✓	✓
7	Erosion of riverbank	Prone/non-existent	✓	✓
8	Flooding risk of offloading site	Likely/unlikely	✓	✓
9	Available stable space at offloading site	Minimal/unlimited		✓
10	Vegetation	Barren/overgrown		✓
11	Distance from waste disposal site	Close/far		✓
12	Ease of person exiting from water	Impossible/easy		✓
13	Water quality (chemical pollution)	Pure/heavily polluted	✓	✓
14	Plastic flux	High/low	✓	✓
15	Size of natural organics	Big patches/small	✓	✓
16	Size of waste	Large/small	✓	✓
17	Water's edge accessibility on foot	Impossible/easy		✓
18	River bank occupation	Urban/natural		✓
19	River bank inclination	Steep/sloping		✓
20	Distance water level to offloading site – horizontal	Large/short		✓
21	Distance water level to offloading site – vertical	Large/short		✓
22	River depth near shore	Deep/shallow	✓	✓
23	River bank/bed composition	Muddy/stone	✓	✓
24	River flow speed	Slow/fast	✓	✓
25	River flow consistency	Intermittent/steady	✓	✓
26	Salinity	Fresh/seawater	✓	✓
27	Tidal range	High/none	✓	✓
28	Flow direction	Unidirectional/ reversing	✓	✓

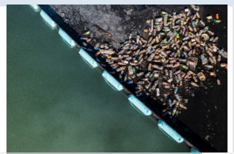
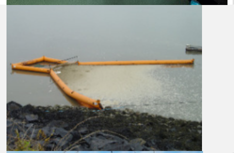
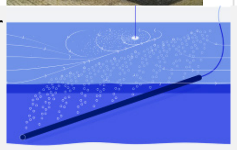
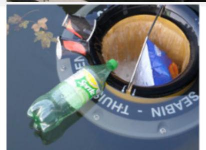
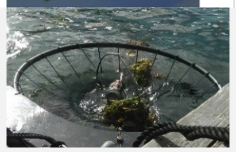
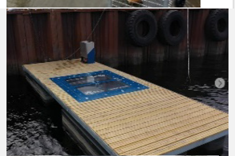
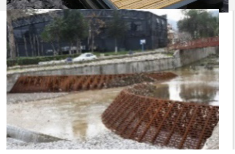
APPENDIX 20: CORRELATION MATRIX OF SITE CHARACTERISTICS

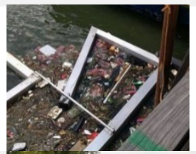
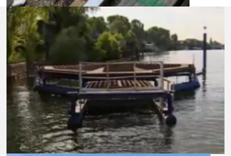
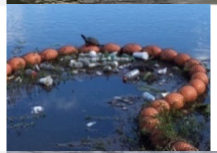
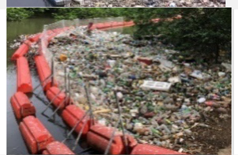
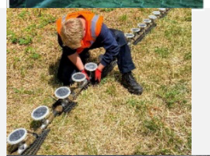
With special thanks to Hidde Coehoorn for compiling all the data after the brainstorm.

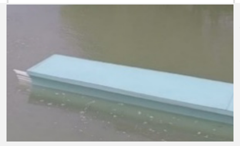
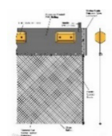
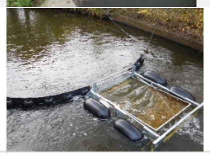
	Flow direction [unidirectional < > reversing]	Tidal range [none < > high]	Salinity [fresh water < > seawater]	River flow consistency [intermittent < > steady]	River flow speed [slow < > fast]	River bank/bed composition [muddy < > stone/concrete]	River depth near shore [shallow < > deep]	Vertical distance (containment area to offloading site) [large < > short]	Horizontal distance (containment area to offloading site) [large < > short]	River bank inclination [steep < > flat]	River bank occupation [urban < > rural]	Water's edge accessibility on foot [impossible < > easy]	Size of waste [large < > small]	Size of natural organics [big patches < > small patches]	Plastic flux [low < > high]	Water quality (chemical pollution) [pure < > heavily polluted]
Water quality (chemical pollution) [pure < > heavily polluted]	0.5	0.2	0	0.5	0.6	0	0	0	0	0.1	0.4	0.1	0.1	0.1	0.1	
Plastic flux [low < > high]	0.2	0.3	0	0.6	0.7	0.2	0.1	0	0	0	0.4	0	0.4	0.1		
Size of natural organics [big patches < > small patches]	0.2	0.2	0.3	0.3	0.5	0.3	0.2	0	0	0.1	0.4	0	0.3			
Size of waste [large < > small]	0	0.1	0	0.2	0.2	0.1	0	0	0	0	0.5	0				
Water's edge accessibility on foot [impossible < > easy]	0	0.3	0	0	0.3	0.5	0.3	0.5	0.3	0.7	0.5					
River bank occupation [urban < > rural]	0	0	0.2	0	0.3	0.6	0.2	0.2	0.4	0.4						
River bank inclination [steep < > flat]	0.1	0.3	0	0.1	0.2	0.7	0.7	0.7	0.6							
Horizontal distance (containment area to offloading site) [large < > short]	0	0.4	0	0.2	0	0.3	0.5	0.2								
Vertical distance (containment area to offloading site) [large < > short]	0	0.2	0	0.1	0.1	0.4	0.4									
River depth near shore [shallow < > deep]	0	0.5	0	0.4	0.4	0.3										
River bank/bed composition [muddy < > stone/concrete]	0	0.1	0	0.1	0.3											
River flow speed [slow < > fast]	0.6	0.5	0.2	0.8												
River flow consistency [intermittent < > steady]	0.9	0.8	0.2													
Salinity [fresh water < > seawater]	0.8	0.8														
Tidal range [none < > high]	1															
Flow direction [unidirectional < > reversing]																

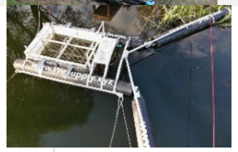
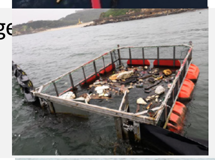
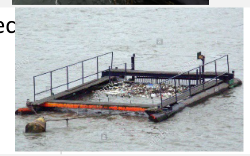
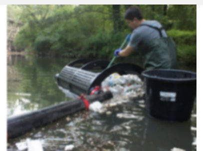
- Strong/definite correlation
- Significant correlation
- Suspected or indirect correlation
- No suspected correlation

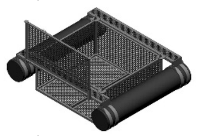
APPENDIX 21: FULL LIST OF EXISTING IN-WATER-WASTE INTERCEPTION TECHNOLOGIES

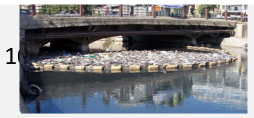
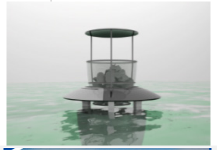
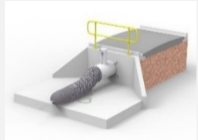
Name	Picture	Company name	Notes	Company website
Interceptor Barrier		The Ocean Cleanup	This barrier is designed with a low centre of gravity to reduce tipping over by the water force	http://www.theoceancleanup.org
Collector		ReCleanSea	Barrier directing debris to net that can be taken out with a boat and manual crane.	http://www.recleansea.org
Everwave Hive X		Pacific Garbage Screening e.V.	Beehive structured litter trap.	https://everwave.de/en/
The Great Bubble Barrier		The Great Bubble Barrier	Only works with low flow speeds.	https://thegreatbubblebarrier.com
River cleaning solution		River Cleaning (MOLD S.R.L.)	Water propelled rotors that direct plastic waste to a net on the side that can be lifted out	https://rivercleaning.com/
Ultramarine/Cobalt		Ichthion Ltd.	Rotor creates stream to capture waste.	http://ichthion.com
Seabin V5		The Seabin Project	Completely stationary creating subtle flow to catch high buoyancy debris. Small capture	https://seabinproject.com/the-seabin-v5/
PortBin		SpillTech AS	Large seabin.	https://spilltech.no/portbin-toolbox/
DLT Demountable Litter Trap		Syrinx Environmental Pty. Ltd.	Sort of lobster trap for waste.	https://www.syrinx.net.au/dlt-demountable-litter-trap/
AquaPod		Clean Sea Solutions	Trash trap designed as dock. Manual extraction through trap door.	https://www.cleanseasolutions.no/product-aquapod
Waste Trap System		The Nature Conservation Centre (DKM)	Basically log booms that look pretty.	https://dkm.org.tr/News/60237c447a406630b1e085d9

Passive Litter Trap		Clear Rivers	Floating litter trap with waste directed to the mouth with a barrier. Manual retrieval of	https://www.clearrivers.eu/litter-traps
Shoreliner		Tauw Group	Litter trap with manual extraction.	https://www.tauw.nl/op-welk-gebied/duurzaamheid/shoreliner.html
Barrages Flottants		SIAAP	Trash trap where doors are opened and trash is extracted with skimmer boat and rakes.	https://www.siaap.fr/equipements/equipements-en-seine/
Watergoat		Watergoat, Inc.	Surface barrier made of buoys.	https://www.watergoat.org
Floating trash barrier		alphaMERS Limited	Simple trash barrier with fence.	https://www.alphamers.com/
B.O.B. (Barrea o Basura)		Marea Verde	Barrier with tipping supports.	https://www.mareaverdepanama.org/projecto-5
Tuffboom		Worthington Products, Inc.	Surface barrier for low flow speeds.	https://tuffboom.com/debris-boom-litter-boom
Odinboom		Worthington Products, Inc.	Surface barrier for medium flow speeds.	https://tuffboom.com/debris-boom-litter-boom
BB20 - Debris Master		Worthington Products, Inc.	Barrier for high flow speeds and floods.	https://tuffboom.com/debris-boom-litter-boom
Bubble Tubing		CanadianPond	Bubble barrier.	https://canadianpond.ca/air-bubble-curtains-bubble-tubing/
Bubble Curtain		ISS Flowthrough	Bubble barrier.	http://www.issflowthrough.co.uk/services/
The Ocean Strainer		MAS Holdings	Surface barrier with manual extraction by raft.	https://www.masholdings.com/plan-for-change/our-planet-changed-for-good/the-

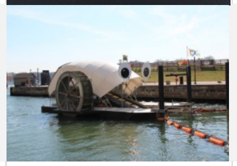
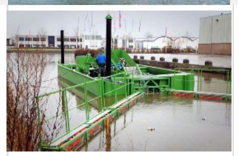
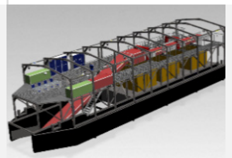
Blue-Barriers		SEADS - Sea Defence Solutions Ltd.	Basic barrier.	https://www.seadefencesolutions.com/blue-barriers/
Plastic Fischer barrier		Plastic Fischer GmbH	Open source barrier with depth for low flow speeds.	https://plasticfischer.com/
Concentration Module		River Recycle	Barrier has turning belt to move the debris to the shore.	https://www.riverrecycle.com
Permanent Fence Boom		Lamor Corporation Oyj	Barrier with depth.	https://www.lamor.com/fi/tuotteet/permanent-fence-boom-mk-8-0
Litterboom		The Litterboom Project	Surface barrier made with long pipe.	https://www.thelitterboomproject.com/about
Debris Booms		Bolina (acquired by Ecocoast Contracting LLC in 09/2020)	Barrier with some depth.	https://www.bolinabooms.com/ourproducts/permanent-debris-booms/
Trident Debris Boom		Darcy Spillcare Manufacture	"	https://www.ind-marine.co.uk/booms/debris-boom/
PermaFence		Elastec	"	https://www.elastec.com/products/floating-boom-barriers/oil-containment-
BruteBin		Elastec	Barrier directing debris into litter trap.	https://www.elastec.com/products/floating-boom-barriers/trash-debris-boom/brute-bin/
Floating Net Boom		Elastec	Barrier with a lot of depth due to netting.	https://www.elastec.com/products/floating-boom-barriers/net-boom/
Bandalong Litter Trap (including Boom System)		Bandalong International	Barrier directing debris into litter trap.	https://www.bandalong.com.au/bandalong-litter-trap.html
EnviRo Enhancer		DESMI Ro-Clean A/S	Barrier directing debris into litter trap.	https://www.desmi.com/enviro-clean.aspx

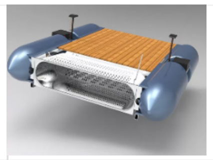
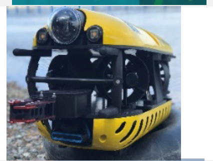
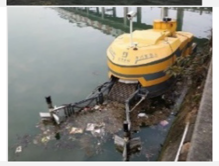
aCycle River Tra		TerraCycle Global Foundation	Barrier directing debris into litter trap.	https://www.terracyclefoundation.org/
Litter trap		SCG	Litter trap with manual cleanout.	https://www.scg.com/innovation/en/scg-dmcr-litter-trap/
.VIR-1		WeSupply	Barrier directing debris into litter trap.	http://www.romania-insider.com/wesupply-river-cleaning-system
r Cleaner		Rivers Global	"	https://rivers.global/en/vietnam-2/#the-river-cleaner-eng
h Trap		Ocean Conservancy	"	https://oceanconservancy.org/trash-free-seas/international-coastal-cleanup/trash-
SH		New Naval Ltd.	"	https://www.oilspillresponse.gr/service-item.php?sid=1
:hy/Patje Plastic		Allseas Group S.A.	"	Patje Plastic: https://allseas.com/project/plastic-collection-system-for-the-port-of-
Sea Floating Garbage Collection Device		-	"	-
;ive Debris Collec		Thames21 Ltd	Litter trap emptied manually by boat.	http://www.thames21.org.uk
:r Gitter		Osprey Initiative	Barrier directing debris into litter trap.	https://osprey.world/litter-gitter
dalong Bandit		Storm Water Systems Inc.	"	https://stormwatersystems.com/the-bandit/
vl		Clear Ocean	Litter trap emptied manually by boat.	https://clearocean.no/about-us/

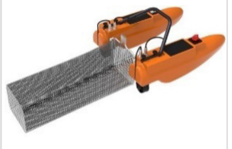
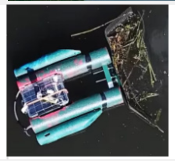
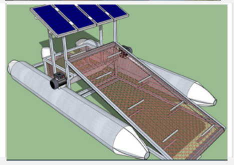
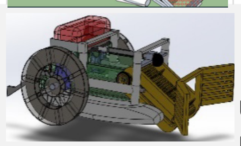
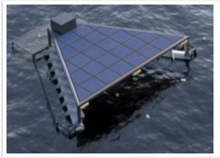
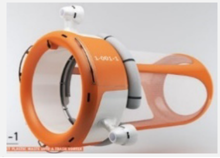
r Skimmer		River Cleanup vzw	Verry basic litter trap emptied by hand from shore.	https://www.river-cleanup.org/en
r Whale		H2OPE S.A.S.	Litter trap with short arms to catch more trash.	https://www.h2ope.fr/en/
Harbor Master FDC / Harbor Skimmer (4oceans)		Marine Dynamics Group LLC	Litter trap on side of dock.	No longer existing
ina Trash Skimm		KECO Inc.	Litter trap emptied with a fish net.	http://www.marinatrashskimmer.com/
ɪnstream Defender		Hydro International Ltd.	Pump that filters water in waste pipes. Integrated in underground	https://www.hydro-int.com/en-gb/products/downstream-defender-
ɪTrap		ENVIROPOD Canada Limited (Stormwater 360)	Litter trap under dock that is emptied from above.	https://www.enviropod.com/products/littatrap
ting Debris Barri		PMS Dock Marine/Dock Marine Systems	Dock/barrier for low flow speeds.	https://dockmarinesystems.com/en/floating-debris-barriers/
der Oil Skimmer		SkimOIL, LLC	Floating skimmer with pump that pumps away water from compartment so trash	https://www.skimoil.com/grinder-oil-skimmer.html
ker		Sungai Watch	Walkable barrier locally produced.	https://sungai.watch/
·Barrier		Matos Teixeira Engenharia e Serviços	Basic barrier with one sided floaties.	https://dockmarinesystems.com/en/floating-debris-barriers/
Floating Litter Trap (Small, medium, large variants)		Mavi Deniz Çevre Hiz A.Ş	Litter trap that is cleaned manually from above. Accessed by walking over barrier.	https://mavideniz.com.tr/our-production/oil-boom-barrier/trash-boom-debris-
River Trash Barrier (Variants 500, 800, 1		Mavi Deniz Çevre Hiz A.Ş	Basic barrier with floaties on both side.	https://mavideniz.com.tr/our-production/oil-boom-barrier/trash-boom-debris-

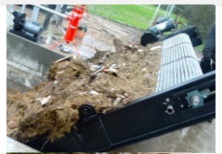
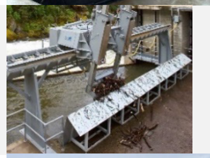
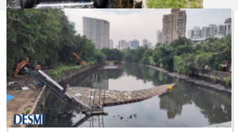
River Trash Barrier (Variants 500, 800, 1		Mavi Deniz Çevre Hiz A.Ş	Basic barrier with floaties on both side.	https://mavideniz.com.tr/our-production/oil-boom-barrier/trash-boom-debris-
		I.S.I.A. Group S.r.l.	Stash trap seabin style.	https://proactiontranshuman.wordpress.com/2014/08/27/jbin-humans-pollute-the-rivers-
ɿ 02		PSP Soluciones	Giant trash trap.	https://www.pspsoluciones.cl/
ɦ Trap		Anacostia Watershed Society	Mesh placed at an angle to filter out trash. Manual removal from mesh.	https://www.anacostiaws.org/what-we-do/river-restoration-projects/pollution-
StormX Netting Trash Trap		Storm Water Systems Inc.	Nets placed at the exit of drain pipes. Twist off, lifted by crane.	http://stormwatersystems.com/stormx-netting-trash-trap/
ɪoGrabber		TecnoConverting Ingenieria SL	"	https://www.tecnoconverting.com/products/tecno-grabber/
ɜol		Urban Asset Solutions Pty Ltd	"	https://urbanassetsolutions.com.au
Anti-macro-waste ne (HR 1000)		Pollustock	"	https://www.pollustock.com/
Large local log booms Malaysia		Berjaya		
Small local log boom Malaysia		Local municipality		

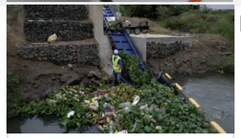
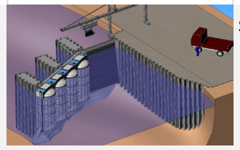
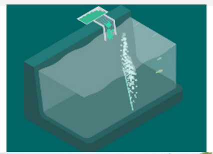
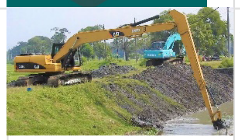
APPENDIX 22: FULL LIST OF EXISTING EXTRACTION TECHNOLOGIES

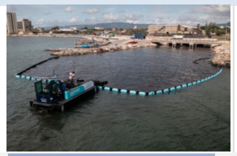
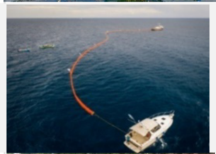
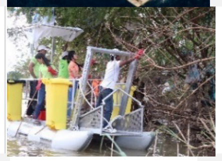
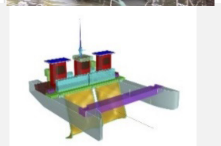
(partly) automated via water				
Name	**Picture**	**Company name**	**Notes**	**Company website**
Interceptor classic		The Ocean Cleanup	Catamaran style where debris flows through the middle where it is picked up by conveyor.	http://www.theoceancleanup.org
Mr. Trashwheel		Waterfront Partnership	Similar to Interceptor Classic. On water power and solar combined.	https://www.mrtrashwheel.com
CTU System (FKA Plasticvisser)		SK International	Similar system as Interceptor Classic.	http://www.skinternational.nl/producten/zwerfvuil-uit-de-rivier.html
River otter		Marine Dynamics Group LLC	"	https://www.marinedynamicsgroup.com/riveotter
River plastic recovery system		Seven Clean Seas	"	https://sevencleanseas.com/
Robotic sorting vessel		Autonomous River Cleanup project (ARC) of ETH Zurich	"	https://riverclean.ethz.ch/
CirCleaner		Noria Sustainable Innovators	Waterwheel turns against current dumping trash in flute.	https://www.noria.earth/
Canal Cleaner		Noria Sustainable Innovators	Turning mechanism moves debris to the containment area.	https://www.noria.earth/
Trash removal device		University of Colorado, Denver	Small scale extraction on water power. Not directly to shore.	https://news.ucdenver.edu/engineering-trash-removal-for-rivers/
River waste cleaning machine		Anjuman college of Engineering and Technology	Mini Interceptor Classic.	http://ijsart.com/Content/PDFDocuments/IJSARTV3I1117780.pdf

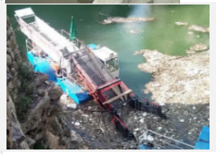
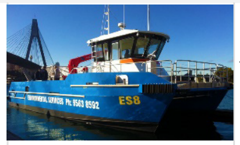
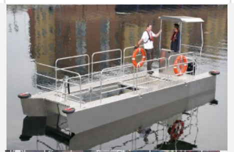
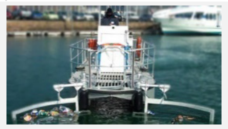
AWARE		DESMI Ro-Clean A/S	Remote controlled trash collector.	https://www.desmi.com/products-solutions-library/aware/
WaterBug		ShoreTech Industries	"	https://lakeweedharvester.com/waterbug/
Geneseas		Recyclamer Innovation SAS	"	https://en.recyclamer-innovation.com/
RiverVax		Bluebird Marine Systems Ltd	Remote or self steering trash collector.	http://www.bluebird-electric.net/oceanography/Ocean_Plastic_International_Rescue/RiverVa
CleaningDrone / AquaDrone		Clean Sea Solutions	"	https://www.cleanseasolutions.no/kopi-av-product-aquadrone
Marine Litter Hunter (Plastiekjager)		DEME NV	"	https://www.deme-group.com/news/deme-deploys-autonomous-plastic-collector-river-
Tortuga		Subsea Tech	"	https://www.subsea-tech.com/tortuga/
Intelligent Cleaning-1		Hefei Institute of Intelligent Machines	"	http://english.iim.cas.cn/news/events/201811/t20181116_201300.html
H3 (Water Intelligent Trash Disposal Robot)		Dongfang Water Conservancy	"	http://www.dfiee.com/content2.html?articleId=118
SMURF-USV (Xpollution, X-cleaner)		ORCA-TECH	"	http://www.orca-tech.cn/index.html
TITAN		ORCA-TECH	"	https://world.orca-tech.cn/product/titan
Waste Cleaning Boat MC120		Oceanalpha USV	"	https://www.oceanalpha.com

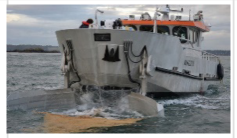
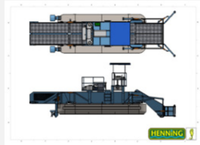
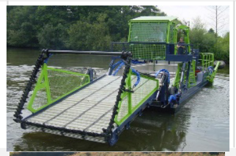
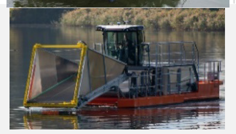
SM800 Unmanned Cleaning Boat		Wuhan Greenbay Marine Technology Co., Ltd	"	http://whgbay.com/en/Product_center/Furniture_lighting/lamp_series/186.html
ClearBot		OPEN OCEAN ENGINEERING LIMITED	"	https://www.clearbot.org/
Trash Robot		Urban Rivers Inc.	"	https://www.urbanriv.org/innovations
Nautonomous		Waternet Foundation	"	https://www.waternet.nl/innovatie/Technologie/de-nautonomous-automatisch-drijfvuil-
Ro-Boat		Omnipresent Robot Technologies Pvt. Ltd.	"	https://sites.google.com/a/omnipresenttech.com/omnipresentrobotics/our-robots-products/ro-
Roboat		MIT in cooperation with Amsterdam Institute	"	http://roboat.org/
Garbage Collection Machine		Green River	"	https://www.facebook.com/greenrivervietnam/
Litter Buster		University Brunei Darussalam	"	https://ubd.edu.bn/news-and-events/news/2021/09/16/litter-buster-could-
Marine Debris Collection System		Technika Engineering Ltd.	"	https://technika-eng.com/technology/deltasea-marine-debris-collection-system.html
Marine Drone		team of private designers led by Elie Ahovi from Institut Supérieur du Design (ISD) Rubika	"	https://www.fastcompany.com/1680195/the-marine-drone-an-autonomous-aquatic-

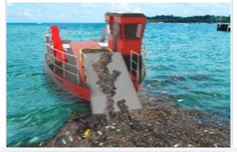
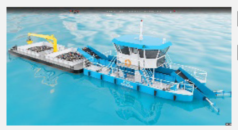
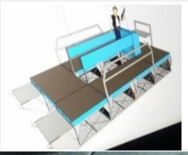
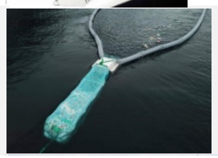
(partly) automated DTS				
Name	**Picture**	**Company name**	**Notes**	**Company website**
Long conveyor for crates		The Ocean Cleanup	Manual extraction, support to shore, pilot.	http://www.theoceancleanup.org
River Recycle technology		River recycle	Long conveyor from floating platform.	https://www.riverrecycle.com
Extraction system A		Chemolex Ltd.	Small conveyor to get the waste from contained area on land.	https://chemolex.co.ke/2021/08/07/plastic-capture-devices/
Extraction system B		Chemolex Ltd.	Arm extended over water like crane. Baskets on simple chain go around like	https://chemolex.co.ke/2021/08/07/plastic-capture-devices/
Extraction system C		Chemolex Ltd.	Turning seesaw mechanism to scoop the trash out of the water and drop it on shore.	content/uploads/2022/06/CCC-Athi-Plastic-Removal-Year-2-report-web.pdf
Extraction system D		Chemolex Ltd.	Basket on a manual pully and slider to lift the trash out of the water.	content/uploads/2022/06/CCC-Athi-Plastic-Removal-Year-2-report-web.pdf
Debris removal screen		International Water Screens	Above streaming water: bridge/dam.	http://www.internationalwaterscreens.com/traveling-water-screens/debris-removal-
Hydro rake		Atlas Polar Company Ltd.	Above streaming water: bridge/dam.	https://www.atlaspolar.com/trash-rake/hydrorake-dt9300-systems.html
Trash rack cleaning system		Gesellschaft für Planung, Maschinen- und Mühlenbau Erhard Muhr mbH	Above streaming water: bridge/dam. Caught by fence like barrier and raked up by mechanical	https://www.muhr.com/en/trash-rack-cleaning-systems.html
Rise		DESMI Ro-Clean A/S	Small conveyor from floating catamaran style platform to land.	https://www.desmi.com/enviro-clean.aspx
Rise with elongation		DESMI Ro-Clean A/S	Locally elongated DESMI Rise.	https://www.desmi.com/enviro-clean.aspx
Sea protector one		All in on green	Barrier blocks waste, once full, arm lifts up and waste lands on conveyor that moves it	https://www.allinongreen.dk/en/om-os/

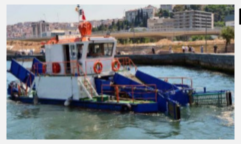
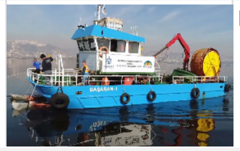
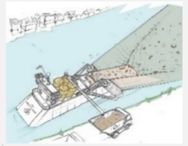
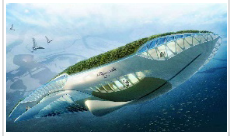
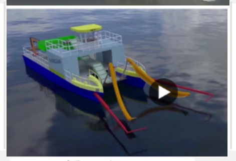
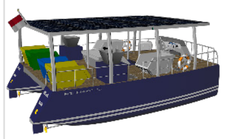
River cleaner		Blue Eco Line S.r.l.	Lots of permanent construction.	https://blueecoline.com/river-cleaner-impianto-ecosostenibile-per-ripulire-i-fiumi/
Automatic river cleaner LEGO model		Mindbreakers e.V.	Conceptual large scale version of Chemolex capture devise with baskets.	https://www.mindbreakers.org/erfolg_2015FLL.html
Azure system		Ichthion Ltd.	Long conveyor with Azure AI to recognize plastics for data and on-site sorting.	http://ichthion.com
Passing river cleaning project		seal mart GmbH	Large scale construction with rake system.	http://seal-mart.com/
Sistema de microburbujas		Inversiones Nauco SpA	Nothing existing except for simple animation.	https://www.nauco.cl/
Excavator		Several companies	Excavators are often used to extract waste from large log booms	

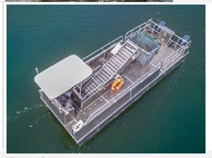
Nonautomated via water				
Name	**Picture**	**Company name**	**Notes**	**Company website**
Interceptor tender		The Ocean Cleanup	Large or small scale manually operated vessel that moves the debris from the water	http://www.theoceancleanup.org
Eco-Boats		Prooceano	"	https://www.prooceano.com.br/site/en/values
Mobile Skimmer		4Ocean International LLC	"	https://4ocean.com/cleanups/
Holy Turtle		SodaStream International Ltd. (Subsidiary of PepsiCo)	"	No website available.
SeeHamster		One Earth - One Ocean e.V.	"	https://oneearth-oneocean.com/en/the-seehamster/
SeeKuh		One Earth - One Ocean e.V.	"	https://oneearth-oneocean.com/en/the-seekuh/
Circular Explorer developed as SeeKuh 2		One Earth - One Ocean e.V. + Holcim Germany GmbH	"	https://oneearth-oneocean.com/en/circular-explorer-by-oeoo-holcim/
CollectiX		Pacific Garbage Screening e.V. (marketed everwave)	"	https://www.garbage-boat.com/en/
Sargaboat / Sargatrailer (barge)		The Ocean Cleaner Inc.	"	https://theoceancleaner.fr/our-boats/
"Underwater Lawnmower"		Cleantec Infra	"	https://www.cleantecinfra.com/
Trash Hunters		Aquarius Systems USA	"	https://aquarius-systems.com/equipment/aquatic-trash-skimmer/
TrashSkimmer		Julong Environment Technology Co. Ltd.	"	http://www.dredgerjulong.com/aquatic-weed-harvester/aquatic-trash-skimmers/trash-

Scavenger 30		Five Aluminium Boat & Engineering Pte Ltd.	"	https://www.fiveab.com/
Aquatic Trash Skimmer		Alpha Boats Unlimited	"	https://www.alphaboats.com/enviramcseries/
Trash Skimmer (DFJB-90)		Qingzhou Dongfang Environmental Protection Machinery Co. Ltd	"	https://dongfangchina.en.alibaba.com/
Trash Skimmer HD (variants 40, 60, 100, 150)		Qingdao Head Dredging Heavy Industry Co.,Ltd.	"	https://headdredging.com/product/category/aquatic_weed_harvester
H2		Dongfang Water Conservancy	"	http://www.dfiee.com/content2.html?articleId=119
"Aqua Explorer"		Clean Waterways Initiative	"	https://www.cleanwaterwaysinitiative.com/
Harbour Cleaner		One 2 three Naval Architects	"	https://www.one2three.com.au/0832-16m-harbour-cleaner
Versi-Cat (formerly Catamaran Buddy)		Liverpool Water Witch Marine and Engineering Co. Ltd.	"	https://waterwitch.com/
Water Witch Workboat Mk.2/Mk.3		Liverpool Water Witch Marine and Engineering Co. Ltd.	"	https://waterwitch.com/
Thames Clearwater		Damen Shipyards Group	"	https://www.damen.com/catalogue/workboats/multicats
NPK20 Water Surface Cleaning Boat		New Japan Marine	"	https://www.collection.njm-sy.co.jp/
Cataglop (Variants 66, 75, 83, 92)		Techmas SPRL	"	http://techmas.com/services/boats-cleaning-water-surfaces-of-sea-harbours-marinas-and-

Workglop (Variants 106, 117, 128)		Techmas SPRL	"	http://techmas.com/services/boats-cleaning-water-surfaces-of-sea-harbours-marinas-and-
WasteCleaner (Variants 66, 66E, 83, 92)		EFINOR Sea Cleaner	"	https://www.efinor.com/entreprises/efinor-sea-cleaner/
MultiCleaner 128 (Variants 100, 105, 117, 128)		EFINOR Sea Cleaner	"	https://www.efinor.com/entreprises/efinor-sea-cleaner/
Mobula 8		The Seacleaners	"	https://www.theseacleaners.org/expedition-mobula/
Kvichak/MARCO Filterbelt Boat		Elastec	"	https://www.elastec.com/
Omni Catamaran		Elastec	"	https://www.elastec.com/
PollCraft (Variants 10m & 12m)		DESMI Ro-Clean A/S	"	https://www.desmi.com/products-solutions-library/pollcraft/
PollCat (Variants 15.5m, 19m, 24m)		DESMI Ro-Clean A/S	"	https://www.desmi.com/products-solutions-library/pollcat/
KaziCat		DESMI Ro-Clean A/S	"	https://www.desmi.com/products-solutions-library/kazicat/
Trash Minder (Variants D-1600 S10, D-7600 S12, D-9200 S16)		Henning Marine	"	http://henningmarine.com/trash-skimmer/
Weed Harvester (Variants 6520, 6540,6925)		Berky GmbH	"	https://berky.de/485-Weed-Harvester.html
Weed Harvester		Conver B.V.	"	https://www.conver.com/en/conver-weed-harvesters/

Truxor (Variant T20,T30,T40,T50)		Dorotea Mekaniska AB (a Lagercrantz Group company)	"	https://doroteamekaniska.se/en/truxor-2/
TrashCat		Mud Cat Liquid Waste Technology, LLC (a Division of Ellicott Dredge Technologies	"	http://www.mudcatdredge.com
Mighty Tidy		Buffalo Bayou Partnership	"	https://buffalobayou.org/
Clewat "Cleaning Device" unnamed		Clewat OY	"	https://clewat.com/en/collection-of-plastic-waste/
OC-Tech 11m		Ocean Cleaner Technology S.L.	"	https://www.oceancleaner.es/products/
Pelikan/ Pelikan 2		GARBAGE SERVICE S.R.L.	"	https://garbagegroup.it/en/boats/pelikan-2/
Zero Emission Working Boat (BNR 158/Bnr-138)		Grovfjord Mekaniske Verksted	"	https://www.gmv.no/vare-fartoy/batterelektrisk/
Sea Hunter		EPS Maritime and Environmental Services	"	https://epsmarine.com/en/sea-hunter/
Sea Hunter Pro		EPS Maritime and Environmental Services	"	https://epsmarine.com/en/sea-hunter-pro/
KDYT 100/200		EPS Maritime and Environmental Services	"	https://epsmarine.com/en/model-a/
M.V. PETÉNYI		PET kupa (Platic Cup)	"	https://petkupa.hu/eng/junk-eating-junk-boat.html
Marine Debris Sweeper 450		LoVeMar AS	"	https://lovemar.no/en/products/

Mini Cat (Variants 5,6,8,10,15)		Mavi Deniz Çevre Hiz A.Ş	"	https://mavideniz.com.tr/our-production/vessels-boats/trash-debris-
Self Unloader (Variant 6,8,10,12,14,16)		Mavi Deniz Çevre Hiz A.Ş	"	https://mavideniz.com.tr/our-production/vessels-boats/trash-debris-
Sea Cat		Mavi Deniz Çevre Hiz A.Ş	"	https://mavideniz.com.tr/our-production/vessels-boats/trash-debris-
M.V. Recyclone		Dyson Ltd.	"	https://www.dyson.co.uk/en.html
Physalia		Vincent Callebaut Architectures	"	https://vincent.callebaut.org/object/100104_physalia/physalia/projects
Floating Debris Extraction Vessel (FDEV)		Beach Protector LLC	"	https://beachprotector.com/
THOMCLEAN		THOMSEA	"	https://www.linkedin.com/posts/thomsea_nous-sommes-tous-daccord-pour-dire-que-le-activity-
Manta		The Seacleaners	"	https://www.theseacleaners.org/the-manta-innovation/
Aquanima (FKA Plakman) Variants 28 & 45		Azura Marine	"	https://www.azura-marine.com
Waste Harvester		Royal IHC	"	http://kunststofkringloop.nl/wp-content/uploads/2014/05/CleanCityDeltaRio_en
Saras-Unit		Saraswater Foundation	"	http://saraswater.nl/en/
Sweeping Arms (MRD-515)		MRD Sweeping Arms B.V. (Affiliated with MRD Marinesupport B.V.)	"	https://www.mrdmarinesupport.nl/en/sweeping-arms

Envirocat Harbour		MMS SHIP REPAIR AND DRY DOCK CO. LTD	"	https://mms-shiprepair.co.uk/envirocat/
Envirocat Marina		MMS SHIP REPAIR AND DRY DOCK CO. LTD	"	https://mms-shiprepair.co.uk/envirocat/
Cleaning Boat		JC France Industrie	"	https://www.jcfranceindustrie.fr/en/cleaning-boat/
The Collector		Race For Water Foundation	"	https://www.raceforwater.org/en/act/the-collector/

Nonautomated DTS
There are a lot of projects where plastic is contained with barriers or traps and taken out manually like Sungai Watch, Pangea Movement , and Plastic Fischer.
Most solutions in the containment methods analysis are also manually extracted.

APPENDIX 23: RESULTS OF BELT CONVEYOR MOTOR SIZING TOOL FROM ORIENTAL MOTOR

Orientalmotor Call 1-800-GO-VEXTA(468-3982) or 1-847-871-5931 Print

- given information -

Load and linear guide

Total mass of loads and table m = 162 [kg]

Friction coefficient of the guide μ = 0.2

Drive pulley specifications

Drive pulley diameter D_p = 107 [mm]

Drive pulley mass m_p = 8 [kg/pc]

Drive pulley length L_p = [mm]

Drive pulley material ρ = [kg/m ^{3}]

Number of drive pulleys n = 2 [pc]

Efficiency η = 100 [%]

External force

F_A = 0 [N]

Mechanism Placement

Mechanism angle α = 50 [°]

Other requirement(s)

Is it necessary to hold the load even after the power supply is turned off? → NO

Is it necessary to hold the load after the motor is stopped, but not necessary to hold after the power supply is turned off? → YES

Operating conditions

Variable speed operation Operating speed V_1 = 100 [mm/s]

V_2 = 300 [mm/s]

Acceleration / deceleration time t_1 = 10 [s]

Stopping accuracy

Stopping accuracy Δl = 20 [mm]

Safety factor

Safety factor S·F = 1.5

- calculated result -

Load Inertia

$J_m = m \times ((D_p \times 10^{-3}) / 2)^2$

$= 162 \times ((107 \times 10^{-3}) / 2)^2 = 0.4637$ [kg·m ^{2}]

$J_{Dp} = (1/8)\, m_p\, (D_p \times 10^{-3})^2\, n$

$= (1/8) \times 8 \times (107 \times 10^{-3})^2 \times 2 = 2.2898e-2$ [kg·m ^{2}]

$J_L = J_m + J_S$

$= (0.4637 + 2.2898e-2) = 0.4866$ [kg·m ^{2}]

Required Speed

$V_{m1} = V_1\,(60 / (\pi D_p))$

$= 100 \times (60 / (3.14 \times 107)) = 17.85$ [r/min]

$V_{m2} = V_2\,(60 / \pi D_p)$

$= 300 \times (60 / (3.14 \times 107)) = 53.55$ [r/min]

Required Torque

$T = (T_a + T_L)$ (Safety Factor)

$= (0.2728 + 75.98) \times 1.5 = 114.4$ [N·m]

Acceleration Torque

$T_a = J_L\,(V_m / (9.55 \times t_1))$

$= 0.4866 \times (53.55 / (9.55 \times 10)) = 0.2728$ [N·m]

Load Torque

$F = F_A + (m \times 9.8)(\sin\alpha + \mu\cos\alpha)$

$= 0 + (162 \times 9.8)(\sin 50 + 0.2 \times \cos 50) = 1420$ [N]

$T_L = (F \times D_p \times 10^{-3}) / (2\,\eta \times 0.01)$

$= (1420 \times 107 \times 10^{-3}) / (2 \times 100 \times 0.01) = 75.98$ [N·m]

Required Stopping Accuracy

$\Delta\theta = \Delta l\,(360° / \pi D_p)$

$= 20 \times (360 / (3.14 \times 107)) = 21.42$ [deg]

Other requirement(s)

Holding Torque

- end of the report -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MODULAR EXTRACTION TOOL FOR RIVERINE PLASTIC WASTE

DESIGN OF A PROOF-OF-PRINCIPLE PROTOTYPE

APPENDICES

Master Thesis
MSc. Integrated Product Design
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