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THREE BRIDGES AND A RIVER

by

GERARD K.H. CHONG

A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

MASTER OF ARCHITECTURE

APPROVED, THESIS COMMITTEE

Carlos Jimenez, Chairman
Assistant Professor, School of Architecture

John J. Casbarian
Associate Dean, School of Architecture

Mark Wamble
Assistant Professor, School of Architecture

Houston, Texas

May, 1999
ABSTRACT

Three Bridges and a River

by

Gerard K.H. Chong

The rapid urbanization of Asia in recent years has radically transformed cities through the incessant barrage of the man-made into the natural. These immense changes are particularly evident in the nation of Singapore where for decades, modernization, urban renewal and industrialization have been the primary objectives of the governing authority. Lying in its wake however, are a series environmental consequences, the results of which are far-reaching and have only recently been addressed.

The Singapore River has through the years suffered such a fate. Once teeming with aquatic life, the river now lays still, healing silently. And while the authorities have since then embarked on major cleaning programs, pollution till today, remains a problem and marine life an uncertainty.

The thesis proposes the introduction of a suite of bridges, a sequence of filtering devices which through serving the purpose of connecting the banks of the river, incorporate secondary functions - cultural, educational or recreational, following the course of the river, addressing the varying conditions along the edges in the attempt to create a new engagement between water and the edge, nature and the city.
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Located along the busy shipping lanes between the East and the West, Singapore's history is often recounted with focus on its humble beginnings as a strategic deep water port. Much of this early rapid growth is attributed to trade and commerce stemming from port facilities as well as diversification of other industries to keep abreast with global economic growth, expanding from the harbor area inland to accommodate the growth. New industrial and housing estate were planned with good infrastructure to sustain growth and provide the public with work places and homes. The drive to excel and remain competitive shaped the nation into a thriving metropolis in Asia within a short period of twenty-five years.

With the intention to guide the city's growth and development for the next twenty-five years, the authorities introduced the Concept Plan (Living The Next Lap, 1991) in 1991, with the island divided into 55 individual DGP (Development Guide Plans) each covering an area catered to a population of around 150,000. Conspicuously prominent in this Concept Plan is the desire to deal with waterfronts and waterbodies, to bring about an increased sense of "islandness", with beaches, marinas, resorts, waterfront housing and commercial activities that embrace the water's edge more closely, signaling the island heritage.

the edge of water
This essay addresses the re-introduction of waterfronts and coastlines to the public and will focus on four aspects relating to the water's edge: 1. Attributes of water 2. Participation on the waterfront, 3. Cultural/religious symbolism of coastal living and 4. Technology and the water's edge. Man's intrigue with the water's edge's is however not limited to the above. Selected to help focus ideas for an urban architectural setting in the context of the city's waterfront, there is also need to understand the opportunities and potentials that can be offered in addressing, architectural programs by the water's edge together with the possible implications of subscribing to the above factors to sculpt an "islandness" environment in Singapore.

1. Attributes of Water. The nature of water and its meeting with land has always held man in awe. Water's significance in a landscape is its ability to complement its surroundings with its varied elemental properties. While visual attraction to the water's edge cannot be easily explained, it plays a primary role in governing our perception and thus forms one of the main factors that attract man to water. The visual impact of water can be understood physically through spatial elements, movement, appearance and the general aquatic environment. The non-visual qualities of water, such as sound, smell, touch, buoyancy and taste together with composite factors of fluidity,
clarity, colors and reflection of light and images are equally important ingredients of its character which contribute to this attraction. Movement brought about by wind and gravitational force set the "mood" and gives us clues about the nature of water on the edge. The physical attributes of land and water bring about the picturesque nature that draws man to the water's edge however, the activities set in the context forms the next attraction to the water's edge.

2. Participation on the Waterfront. Participation here is seen as man's desire to live, work and play in harmony with the elements in nature. A walk along the water's edge, in an urban or rural setting not only provides visual pleasure but also therapeutic value that is hard to quantify or qualify, resulting in a progression of activities related to leisure, recreation and sports by the water.

In Singapore, competition arising for the limited coastal area has resulted in allotment of only a small part of the coastal area for the development of recreational facilities. Over the years, coastal parks and beaches (e.g. East coast park, West coast park, Changi beachfront etc.) were planned and developed to meet the public's demand for areas to retreat from the city. These planned water edges are mainly reclaimed sandy beaches, inter-spaced with headland breakwaters. The activities that occur take place simultaneously emphasizing
the fact that activities draw people, and people attract more people to the water’s edge. Common activities seen on the beaches are that of family picnics, group outings, fishing and swimming.

The Singapore River area under investigation in this thesis stretches for some distance and could be punctuated with activity nodes, focal points, and bridges and be connected with circulation routes. Park infrastructure and landscape could likewise be integrated with this overall plan to ensure ease of maintenance and public use. Currently these plans are being addressed and with the population expected to grow in the following years, there will also be a need to address the question of expansion. Accessibility and potential for recreational and commercial development along the river’s edge are thus crucial in addressing this. Changing patterns of public must also be taken into consideration, taking cues from the increased desire for night activities, waterfront activities could be planned to accommodate this trend.

Expanding the existing edge area for activities with the introduction of piers extending from the land out onto the water is one possible avenue of exploration. The pier represents a form of architecture that characterizes the seaside resorts and can be seen as a punctuated activity zone extending edge activities out on a platform floating or
otherwise. An adapted regional example of the same concept is that of the local 'kelong' restaurants. These restaurants are designed with limited accommodation and facilities where diners are ferried to these structures for seafood buffets set in the ambience of fishermen's' work place. These structures scattered off-shore not only provide a picturesque setting but also develop a dialogue between the activities along the coast and the off-shore which contribute to the attraction to the water's edge.

3. Cultural and Religious Symbolism Relating To Coastal Living. Water culture and religious symbolism are manifestations of communities that originate or are associated with the water's edge. Water is perceived as the original holy liquid and in almost every religion or mythology includes a belief in the sacred properties of certain waters. Culture and religion fuse water bodies and land elements with the metaphysical perception of man's place in the cosmological order of the universe.

Such water developments and coastal living habits are not new or unusual in Asia. Water communities such as these can be found in Bangkok, Thailand, where houses and work places are built on piles rising above the coastal waters of the Menam River. The people live, work and commute within the informally organized parameters and set up buildings in
and on water to form waterways and common market areas. Singapore's early history shows predominantly timber built forms over water for commercial and residential use. The Malay settlement of Pulau Seking, Singapore, located 7km off the southern shore of mainland Singapore, is one such example. Here the planning of the architecture is governed by the Adat, a Muslim set of social and cultural orders that mould the physical built environment to suit every day conduct and values of the community. The community also practices animistic religion (religion of the early settlers on Pulau Seking a belief that the living soul should not disturb the abode of the dead as a form of respect to the dead) and living on or near the cemetery is not in harmony with the order of the metaphysical world resulting in the settlement shifting towards the water vacating the land for scared use.

Kukup Village of West Malaysia is another example close to Singapore. This Chinese settlement was built on the seaward side of a mangrove swamp to facilitate commercial fishing activities. The general layout of the village is governed by Fenq Shui or geomancy which stress the importance of harmonizing with nature. Water elements are symbols of wealth and is thus auspicious to build dwellings fronting them. This metaphysical belief coupled with the needs of the fishing
village led to the coastal settlement pattern, centered around work activities, planned around water based transportation and ordered by religious/cultural practices.

Waterfront communities too will become a reality in Singapore by the year 2000 with the development of the master plans for Simpang, Punggol and Tanjong Rhu coastal areas. The strategy to attract people to the water’s edge is to provide good and efficiently planned developments with emphasis on water-related activities. The overall concept plan for the city proposes an identifiable ‘coastal town’ with medium and high-rise housing, marinas in resort settings along the waterfront. In addition, the idea of integrating marinas within the development of the master plan opens the coastal waters to those who may only want to invest in yachts, power boats and club memberships for recreational purposes. As a result, a whole range of water based service and support industries will grow while new housing guidelines, water usage and pollution control means will have to be addressed.

On the technological front, these developments will push forth new models, tropically considered and designed to meet regional environmental conditions. Coastal communities and marinas will possibly lead to the reintroduction of commuting by waterways around the island forming an important attraction to the waterfront. The concept plan has identified

the edge of water
new ferry landing points relating to coastal planned communities to form a ringed route around the country. This will not only give Singapore an alternative means of commuting but give tourism a boost to explore Singapore and the neighboring islands, to accommodate links between Singapore, Malaysia and Indonesia.

4. Technology and the Water’s Edge. The relationship between water and land is primarily expressed at the boundary where the two elements meet. The material use and the gradient of the edge suggest the forces of water acting on land and present opportunities to designers in considering critically the edge of water. The use of appropriate technology to overcome storm conditions to create protected waterbodies for related activities is another factor that will assist in attracting people to potential the water’s edge. By exploring the various configurations of the water’s edge, a greater parameter for design may be achieved, altering the dimensions of the water’s edge to encourage activities and dialogue between man, land and water.

Bridges are often introduced to link two edges of a water body overcoming the barriers created by water (e.g. Sheares bridge and the land bridge from Singapore to Sentosa and the bridges that span the Singapore River). These structures spanning the water bodies command
attention and present opportunities of extending the activities across to the other sides.

Singapore's water edges are only just now being realized as potentials and assets to the nation. Much effort has been made to improve on the quality of existing water edges as well as increase the edge itself. Through careful planning, Singapore will add another chapter in the quest to becoming a global island city-state.
This project is a proposal for a river, a proposal that seeks to allow one to engage with and understand the nature and importance of water and the various ecosystems that are dependent on it, and what the carelessness of man can and has done to impact the environment, to affect this very delicate balance. With the initial interest in water, the thesis then proceeds with research into the nature of water and its relationship to people, especially in Asia with the aim of discovering alternative possibilities for a more critical land/water, man/nature engagement to occur, for an architecture to exist with water.
Located at the southern-most tip of the island of Singapore, the Singapore river is perhaps the best known river in the country. It is however a polluted one, almost totally devoid of marine life and only until recently beginning to recover from the effects of pollution of the past.

In the days of the British rule, the Singapore River was the umbilical cord of the city, thriving on the abundance of trade along the river alone. And like most port cities of the world, this phenomenon gradually subsided, as the city grew inland away from the river. The River then was merely treated as a waterway, sewer, and a rubbish dump which ultimately led to the extermination of all marine life forms that once flourished in the estuary.
In the 70s, the river badly polluted with sewage, domestic refuse, and industrial waste as well as animal and farm waste, became a place the people would avoid rather than enjoy. In 1977, a clean river's act was implemented to clean up the river and the authorities promptly took action on a massive cleaning and clearing up operation. In all, the water cleanup effort brought about the resettlement of 26,000 families from substandard housing, the relocation of 5,000 street hawkers into food centers, the removal of 2,800 river industries and 610 pig farms.

The last major action was the clearing away of the small wooden 'bumboats', that once lined the riverfront. In September 1983, 800 were moved down the river to a new anchorage, marking the end of a tradition that went back 160 years.
Long Term Management and Control measures include: 1. Prevention of litter entry through the covering of drains in litter prone areas with slabs, 2. Installation of vertical grating at selected outlet drains leading to main canals and rivers and 3. Installation of floatbooms across rivers and canals.
Today, however, despite all the efforts by the authorities with the cleanup efforts, moving along the edge of the river from inland out towards the mouth of the river, pollution as well as the foul smell that accompanies it still persists. This diagram basically describes the distinct characteristics/zonal differences along the river’s edge illustrating the essence of each point along the river, from an area with a relatively more natural setting to one of a highly dense urban setting. It also shows the various types of marine lifeform that have been found in the river recently.

Corresponding to this, is the increase in effluence, pollution in the river. The start of the river inland is also the point where the river is most polluted.
The initial investigation of the site involved the analysis of the entire length of both edges of the river from the mouth to as far inland before the river transforms into a rainwater canal/drain.

The primary goal was to observe the changes in the edge condition of the river and to document the existing infrastructure over and around the river.
1. Kim Seng Bridge (built 1955)
2. Pulau Saigon Bridge (built 1997)
3. Clemenceau Bridge (built 1989)
4. Ord Bridge (built 1886)
5. Read Bridge (built 1889)
6. Coleman Bridge (built 1886)
7. Elgin Bridge (built 1822)
8. Cavenagh Bridge (built 1869)
9. Anderson Bridge (built 1910)
10. Esplanade Bridge (built 1997)
A total of ten bridges span the river, bridges ranging from the days of British rule to the most recently completed one, the Esplanade Bridge at the mouth of the river.

The authorities are also in the development guide plan (DGP), planning the construction of 3 additional pedestrian bridges which will be located deeper inland near the source of the river, facilitating greater connectivity of the banks.
This set of photographs are views of the river as seen from the ten bridges, showing clearly the transition from the less built up, more natural part of the river to the denser, more urban financial center of the city.

The river also widens considerably from a width of 50 m at its narrowest end to a maximum width of 160m at its widest point (Boat Quay).
Approximately 3km in length, the river traverses 3 distinct zones of the city with highly identifiable characteristics, architecturally as well as programmatically. Moving from the inner reaches of the river outward towards the mouth, the landscape changes dramatically from a less dense residential/retail zone to a noticeably denser commercial/business district. The 3 distinct zones have been identified and categorized by the URA (Urban Redevelopment Authority) as the Robertson Quay Area (residential/hotel zone), the Clarke Quay Area (commercial zone/active) and finally the Boat Quay Area (civic and cultural zone).
The following set of diagrams graphically breakdown the site both above and around the river.

The various constituents of the site are categorized into the following:
1. the transportation network, 2. the residential/commercial zones and 3. the existing green spaces around the river area.
This set of diagrams illustrate the major trunk roads crossing 7 points of the river with 3 remaining bridges catered solely for pedestrians.

Also indicated in the diagrams are the locations for the 3 additional pedestrians bridges proposed by the URA (green on the bridge diagram) to be completed by early 2000.

The second diagram shows the inaccessibility to the edge of the river, a situation that the authorities have identified as a problem and are in the process of rectifying.
The following diagrams illustrate the commercial/residential breakdown of the area around the river. The yellow represents the residential blocks and the red represents the commercial, clearly indicating an almost balanced distribution across the length of the river. This breakdown corresponds to the dual characteristic condition (natural/urban) along the length as well as the 3 zones of the area. This condition (temporal) becomes apparent through the course of the workday as the level of activity subsides from the commercial zone moving towards the residential after work and vice versa at the start of the day.
The final set in this series of illustrations show the concentration of existing green spaces of the site and the eventual siting of the proposed bridges along the river.

The placement of the these bridges are in this case determined not only by the by the green spaces, but also by the 3 zones of the river and the natural/urban condition of the site.

Also affecting the locations of the bridges are the future development of a subway station at the Clarke Quay zone and an existing one located at the Boat Quay area.
The river diagrams illustrate the various conditions that the river experiences or has already gone through and are categorized into the following: 1. Water maintenance devices and the effects on the river, 2. Floating vessels allowed in the river and the corresponding depth and dredged portion of the river, and finally 3. Marine life found in the river and the corresponding location and their likely concentration.
The Singapore River is an artificial estuary, tidally influenced, and where river meets the sea, freshwater with salt water. Estuaries in their natural states provide: 1. Habitats for birds, mammals, fish, and other wildlife dependent on it. 2. Nursery for marine organisms, where most fish species depend on estuaries at some point during their development. 3. Productivity with untended estuaries producing from four to ten times the weight of organic matter produced by a cultivated corn field of the same size. 4. Water filtration draining off loads of sediments and nutrients creating cleaner and clearer water, 5. Flood control where porous, salt marsh soils and grasses absorb floodwaters and dissipate storm surges.

The estuary functions as an efficient nutrient trap that is partly physical and partly biological. Three major life forms of photosynthesizing organisms play key roles in maintaining high productivity by exploiting nutrient sources: 1. Phytoplankton, suspended within the sunlit zone of the water column, 2. Benthic microflora, microscopic plants living on the sediment surface wherever sufficient light reaches the bottom; and 3. Macroflora or rooted plants and rootless algae grow in shallow water and along the shoreline.

The more the river returns to this condition, the better it will be for the life that it supports. While it is not likely (nor is it the ultimate goal of this project) that this will be achieved, other forms of management could and should be implemented to further improve the quality of and cleanliness of the river.
The color used on this set of diagrams describe the concentration of pollution found in the river, ranging from a more polluted region (indicated by the darker orange) to a less polluted one at the mouth of the river (lighter orange).

The second diagram in the set shows the current state of pollution of the river. Next to that, the first diagram shows the estimated reduction of debris in the river as a result of the placement of the proposed bridges.

Already employed devices currently found in the river are the debris removal device (located at inland near the start of the river) and makeshift nets placed under bridges at various points along the river as seen in the photographs above. While effective, these measures are temporary and unsightly.
The tides in Singapore are generally semi-diurnal with two high tides and two low tides occurring each day caused by the gravitational forces of the moon and the sun with the former exerting the stronger effect. A time lag of 51 minutes exists between successive alternate high and low tides coinciding with the lunar day of 24 hours and 51 minutes, the time taken for the earth to complete one full rotation and to come to the same point facing the moon that is itself orbiting the earth.

A tidal range (the difference in height between each cycle's high and low tide) of 2.5m is common during spring tides which occur fortnightly at full or new moon. The neap tides in between have a smaller tidal range of as low as 0.7m. Also, the extreme spring tides can reach a maximum height of 3.5m and a minimum low of –15cm, achieving a tidal range of 3.65m. This tidal range also decreases gradually eastward in the Singapore Straits as it approaches the open sea.
This set of illustrations describe the depth range of the river and the length of which already dredged. The dredging of the river began in 1977 and has been going on till today, initially an operation to clear out debris from the bed of the river but now to also increase the overall depth of the river.

Only vessels specified by the Port Authority of Singapore (PSA) are allowed to navigate the river, almost all of which are commercial operations, providing river cruises for tourists.

The only other vessels allowed on the river are the barges used to carry away the dredged mud and debris and the floating 'Tong Kangs' most of which have been converted into floating restaurants.

No pleasure crafts are permitted in the river and no vessels are allowed beyond the Clarke Quay zone (Read Bridge).
Marine life, previously almost nonexistent, is slowly returning to the river. Recent findings indicate the presence of various species of marine organisms such as groupers, snappers, gizzard shads, pony fish, silver bellies and crustaceans like the flower and mud crabs and sand shrimps, all of which however have not been able to establish niches in the river.

In an effort to enhance the fish population of the river, the Primary Production Department initiated a ten-year stocking program which began in 1986, aiming to eventually establish the stocked fish as resident species, and promote game fishing in the Singapore River. So far, over 80,000 seabass (Lates calcarifer), 8,500 cherry snappers (Oreochromis niloticus) and 630,000 banana shrimp (Penaeus merguiensis) have been stocked, however, sampling results suggest that only the seabass have been able to establish a niche in the river (Tan 1986; Yip et al. 1987; Khin and Chou 1991).

Another resident organism of the river is the marine worm (28 different families). The importance of marine worms (polychaetes) is significant to the maintenance of the river. These include: 1. Economics - as marine worms are an important food source for many economically important fish, 2. Biomonitoring the environment – importance of these creatures in monitoring the ecological impact of effluence and pollution (pollution indicators), 3. Accessing the toxicity of sediments and monitoring the marine environment.
The first diagram shows the 'hot spots' along the edges of the river as determined by the activities found there. Establishments such as restaurants, bars, and shopping centers have slowly been sprouting along the banks of the river, cashing in on the public's renewed interest in the relatively less polluted river.

The next diagram illustrates the estuarine characteristic of the river changing from freshwater to brackish and then finally to seawater. While the river has lost most of the capabilities/capacities of estuaries, the freshwater/seawater concentration still fluctuates with the tides.

The blue shows the current location and concentration of marine life that can be found in the river, mostly fish that come in and out with the tides.

The photographs above are some of the marine fish that have been found in the river.
The proposal for this project is fourfold. Primarily for the purpose of connecting the banks of river, especially where traffic (the bridges proposed in this project are solely for pedestrian use) is heavy, the bridges will also include secondary programming and will serve several other purposes: 1. The bridge will act as a filtering device, a scientific device which through the natural flow of the river, allow the river to cleanse itself, mimicking that of natural estuaries where the cleansing actually occurs as the water flows over and through the seagrass embedded in the river bed. 2. Bridge as a scientific monitoring and nutrient replenishment device. The bridge also proposes to function as an eco-monitoring device, maintaining the state and condition of the river as well as supplying the river with nutrients necessary for the survival and flourishing of marine life. 3. Bridge as focal point along the river. In line with programming, the bridge will also accommodate functions which may make the bridges destinations in itself giving the three different bridges distinct characteristics, distinguishing one from the other along the length of the river and finally, 4. The bridge as an informational device. Programming that occur on the bridges may begin to inform the public and create an awareness of the importance and delicate nature of the river.
Site.01 is situated at the innermost portion of the Singapore River, where the surroundings are relatively less developed and less dense. This part of the river has been designated by the URA as a residential zone, adding to overall calm/serene nature of the area in general.

Here, the bridge will incorporate a bio-research laboratory which together with the structure will act as a filtering device, allowing the river to cleanse itself as the water flows under it with the tides. In addition, biological/scientific research will be carried out in the bridge itself, allowing researchers to monitor and improve the quality of the water in the river, replenishing the river with nutrients necessary for the survival and flourishing of the marine life present in the water.

As this part of the river is also the narrowest with the most natural setting, the bridge will be less imposing, blending seamlessly into the surroundings.
The second site for the suite of bridges is located between site.01 and site.03 and falls in the Clarke Quay area where a soon to be completed subway station is located.

The proposal here is for a bridge that will incorporate two other programs: a fish hatchery and a marine library, each functioning to cater to both the social and aquatic realms.

On the social component, the bridge will act as an informational device which will begin to inform the public and create an awareness of the importance and delicate nature of the river and the marine life that depend on it. The bridge connects the subway station to the other bank of the river optimising the heavy human traffic for this primary purpose.

On the aquatic side, the fish hatchery proposes to continue where the Primary Production Department has left off supplying and replenishing fish stock in the river as the river becomes cleaner. Scientific research will also be catered for in this bridge as will that of the final bridge in the suite.
The final bridge in the set of three will be located at the Boat Quay zone, nearest to the mouth of the river before heading out to open sea. This portion of the river is also the most dense part of it, and is primarily occupied by tall office skyscrapers, making up the financial center of the nation. In addition, the river here also swells to a maximum width of 160m at its widest point, a point affectionately known as the ‘carp’s belly’.

The bridge proposed for this part of the river is a river aquarium bridge where part of the attraction of this aquarium is exhibition of the local fish that exist in the river itself. The bridge here acts as a focal point along the river accommodating the aquarium component function making the bridge a destination in itself.

All three bridge work together to clean, replenish and educate, all for the ultimate goal of reviving the once flourishing river.
The following series of diagrams lay out the objectives as well as the influencing factors affecting the form and functions of the bridges, where these bridges would take on different relationships to the water informed by traditional structures or vessels that exist next to, over or in the water. Through research, several traditional water-related structures were found and adopted as reference points for the design of the bridges, setting up a framework, a set of operational rules that would accommodate the 3 bridges.
Existing close to site.01 is a river debris removal station, located on the left bank at the innermost end of the river. This device literally sieves the water and picks up through its mechanism, debris from the water, effectively removing trash from the river. While adopting this into the structure of the bridge, the bridge here also serves as a bio-research lab for scientific experiments to be carried out on the river. Experiments that would test the toxicity of the water and to document the various types of marine life.

The last diagram illustrates the changing/varying social and aquatic relationship that the bridge proposes to address and create along the river in relation to surroundings. The priority of focus on which the bridge will serve will vary from bridge to bridge. From one that would focus solely on the condition of the water to one that focuses more on the social condition, and in this instance, the priority of this dual relationship will be on the aquatic.
In the second bridge, the traditional ‘Tong Kang’ and the floating barges were used as reference points. The main idea for this bridge was that the hatchery/library would have a tidally dependent device that would fluctuate according to the tides of the day and will engage the public with its dynamic condition. This structure will also incorporate the vertically protruding poles of the ‘Kelong’ (on following page) in its structure as will the final bridge in the series.

The hatchery/library bridge serves as both an informational device (library component dedicated to the oceans and rivers of the world) and a replenishment agent (hatchery component dedicated to all ecologies related to water).

Here the proposal of the bridge is one that focuses equally to both conditions/realms as indicated by the last image in the set.
For site.03 in the proposed aquarium, ideas of funnelling, directing and sieving were adopted from the 'Kelong', a traditional fishing structure. While the kelong was used primarily for the purpose of catching fish, the bridge in this case only utilizes the notion of channelling marine life along a path against the sides of the aquarium allowing visitors to view the marine life in the river.

The final bridge in this sequence serves as a testimony to the work done by the set of bridges, the results of the filtering of the river and returning life back to the seas.

The aquarium not only allows the visitor to become aware of the marine life in the river but also get to see it in its natural habitat. The aquarium also provides a breeding alcove for the fish to spawn.

The final diagram illustrates the focus of the bridge directed on the social component, completing the series.
The following set of images breaks down the various devices selected as references for the final form of the bridges.
This set of diagrams basically break down the river debris removal device into its constituents members. The diagrams show the basic operating mechanism, a relatively simple device that literally filters the water which pass through its grates. When debris gets caught by the vertical grates, another set of protruding teeth perpendicular to the grates moves upwards and lifts the caught debris. This debris is then lifted over the top and unloaded on the other side into trash receptacles. The more debris the more receptacles and the device will also have to face the direction of the incoming current to operate. The device however need not be in continual motion, operating only when enough debris gets caught.
The analysis of the ‘Kelong’ structure illustrates the dialogue between the structure and the water also extending vertically from the above to under the water realm.

The primary accommodations of the kelong sits above the primary device, the trap. The trap consists of a net and the vertical poles which surround it forming an inescapable cage trapping fish within.

The next part of the kelong is the neck which connects the dwelling/device to the funneling, channeling poles. The neck doubles as the bridge (above water) as well as the opening to the enclosure below the dwelling (under water). The bridge allows the fisherman to walk over to the poles that require repair.

Finally 2 arms of poles stretch out in the direction of the tide guiding fish into the trap. Above the water they sometimes serve to bridge the structure to land while below, functioning as a ‘fish funnel’.
This set of images break down and distills both devices into their constituent components and the final image shows the combination of the elements from both devices in a typical setup. The prototype device proposed is a modular filter bay that can easily slot itself into the gaps of the columns that support the structure above. This device can quickly be replicated and assembled in other situations and rivers where necessary.

In all three bridges, the device is employed to varying degrees depending on the level of pollution but all operate in tandem with one another and with the structure of the bridge.
This is an additional device proposed to complete/complement the sequence of bridges. The pollutant level indicator allows the public to view and understand the purpose/ functions of the bridges as a set operating together.
The device is simply an encased glass cylinder displaying the level of contamination in the river at that particular point. The device has on its outer shell a graduated color bar indicating the matching level of pollution color which one would match to get an idea of how polluted the water is. These indicators are however not a perfect indication of the level of toxicity or pollution in the water and is meant only to allow the public to understand the purpose of the bridges.

The glass cylinder will have connecting pipes below the base that will constantly circulate with the water in the river and the indicator bar will be updated periodically as the level of pollution in the river decreases.

In addition, each bridge will have two other indicators displaying the water at the other two points, allowing one to make a comparison of the different conditions of water over the length of the river.
This diagram shows the longitudinal section across the length of the river with all three bridges located based on the findings from the preliminary analysis of the site, relative to the green spaces, major train stations and various zones along the river. All three bridges adopting the same set of operational rules in their overall form.
The indicators will be placed uniformly across the length of the river at about 100m intervals and will become part of the proposed promenade that the authorities are currently constructing.
three bridges and a river
bridge.02 - marine library/fish hatchery
(bridge side elevation)
Background and Historical Information (Singapore)


Ng Poey Siong, Singapore Facts and Pictures, Ministry of Information and the Arts, Singapore, 1996.


New Downtown – Ideas for the City of Tomorrow, Urban Redevelopment Authority, Singapore, 1996.


Tropical architecture and water


Man/ Water, Sea/Land Relationship


Ecological/Sustainable Architecture


Oceanic architecture

Process Architecture 96 – Composition of Oceanic Architecture, Murotani, Tokyo, 1996