

FLOOD ALLEVIATION METHODS AND SYSTEM FOR URBAN OPEN CHANNEL NETWORK

FIELD OF INVENTION

[01] The MoFlow Process relating to maximize water network function, alleviate flood, increase reservoir storage, creative land utilisation, maximize “Active Beautiful Clean” (ABC) potential.

BACKGROUND

[02] In all urban drainage channel system, the surface rainwater is collected into open drain channel. The accumulated water from multiple areas then discharges off its water to a connecting common main discharge channel and ultimately discharge off to an outlet waterbody at reservoir, lake, river or sea. Overtime, urban development or redevelopment changes the built-up area and also changes the drainage merging flow input connections. The change of input connection also changes its back flow characteristic from its original merging condition.

[03] The new confluence changes the water input mixing rate. It also changes the flow pressure and create new water level to its upper and lower connecting channel section.

[04] When there is a new major development in a neighbourhood, it is potentially possible to covert a historical non-flood area to a flood prone area under the same rainfall condition.

[05] Theoretically, the upstream drainage should be smaller in size and expand gradually towards the lower section like river. In a matured city, due to the past flood or water ponding experience, the newer waterway was built for larger capacity as compared to the older waterway. This is to cater for the backflow water to prevent flood. Such drainage waterway section is likely to end up with an unnaturally layout with a smaller size midstream as compared to the much larger at upstream and downstream drainage functioning dimension.

[06] The urban surface drainage channel network is developed over different stages of urban development. This drainage network continues to lengthen during development and changes during redevelopment.

[07] In the drainage system, beside the elevation, size and length there are many confluences were built to fit requirement to the need of particular time. Overtime, the channel increases in length so as the number of confluences. Due to the cross-flow arrangement, these confluences

induce back pressure energy leading to water back flow, this generated energy delay and hold water flow within the drainage network.

[08] When there is a change of use on a major land plot or many land plots are redeveloped into a single development, it changes the drainage discharge location and dimensions. This larger confluence may affect the common channel water flow and nearby smaller confluences functioning as compared to its past discharge performance.

[09] In most established urban area, there is limited possibility to expand the waterway. The function of drainage system is like a living thing, its fitness changes overtime. The accumulated development changes and its restriction of flow may lead to a flood condition during a heavy rain storm. In most case, the drainage in area which experiences flood is likely has limited space or option for any drainage waterflow improvement.

[010] Imagine, what if the road traffic network in the city is without the traffic light control!

[011] With a rational management on water flow improvement, we are able to manage the water level and its back pressure flow energy within a drainage system. This flow management improvement system is by addition of flow control fixtures into the current drainage network system to function for all known rainfall conditions to lower the water flow level, also to alleviate water ponding and flood problem.

[012] In any natural water stream, as the stream is accumulating more water along its way downward the lower-stream section is always larger than its upper-stream.

[013] Generally, township formation is from low land near water, it expanded towards upstream higher land and continue downstream to lower land and shallow water. Ultimately, the shallow water was reclaimed to land from water. Due to the past flooding experiences, the township waterway network growth also ended up with an unnatural waterway arrangement of Large at upstream and downstream with midstream in smaller section. This formed the unnatural Large-Small-Large layout in a city.

[014] When city continue to grow and redevelop, land plot size changes but the drainage remains. Such situation just added up to an unbalance drainage network and subject to frequent flooding. In most established urban area, the existing physical constrain on elevation and size of drainage are the limiting factors for flow improvement. The back-pressure-control system is a solution to correct such

flow restrictive physical condition as there is no such known existing corrective improvement process in application.

Water Ponding in Catchment Area

[015] Flood happens at certain section of drainage system when high water level overrun its channel wall. When a larger catchment area of multiple drainage network groups discharges its water to a common main discharge channel. During a flood, the problem water may not necessary be the surface water collected from that local area. This flood water can be due to back flow water from other network water within the larger common catchment area. Such flood water is often built up due to the flow restriction from a major confluent at lower stream.

[016] In the changing weather world today, we should manage the waterflow in open channel like the road traffic as the ultimate objective. The current waterway is not young anymore, just like those expressways for land traffic were built decades ago is already pack and jammed during every peak hour in most days. We should manage the water flow in the waterway like managing the road traffic.

[017] There are many ways to prevent a flood as it is similar to road traffic jam. Beside upkeeping its functional condition and increase its water holding capacity or raise the drain-wall height, we have yet to manage the water flow condition in the drain through back flow pressure management.

[018] To improve water discharge condition, we have the options to streamline the downstream water flow; to lower the downstream water level by diverting water to any connecting channel with spare capacity; and similarly, hold any upstream water by delaying flow or shift further up or divert to other connected upstream channel with spare capacity to store water with its potential energy. The delaying of upstream water flow also lowers the downstream transient water level rise. It also reduces the downward flowing water pressure.

[019] To resolve a particular water ponding area, it is necessary to understand the nearby connecting drainage confluence flow condition. To manage, we need to clear the downstream passages and hold the up-stream water to ease discharge flow restriction near the flooding area.

Flow Predictability in Rigid Channel Design

[020] Drainage construction design has its limitation on capacity adjustment to handle changes to flow input. No open Channel drainage network system can be design or built to cater to maximum water level discharge unless its water input maintains a constant flow volume/energy. In reality, drainage connections and input changes overtime are subjected to development and redevelopments.

[021] Raining season is relatively predictable, but rainfall is not. In a small island Singapore, the rain fall is not as predictable to any specific location or catchment area as compared to a larger landmass country. Heavy rainfall covering the whole island for long hours or days is not common for Singapore. Heavy rainfall on to the whole catchment area is common. The raincloud drift according to wind direction so as the rainfall drift from area to area and follow on. When the rain drifts from a catchment area to another catchment area, this changes the water input / collection and its drainage discharge pattern. This changing of the rainwater input result to shifting of its water merging flow pressure and shifting water level in drainage.

[022] The urban waterway flow capacity has been designed based on historical rainfall in any catchment area. Such waterway settings were built over time according to physical infrastructures like roads or buildings. In some areas on drainage network that experiences frequent flood occurrences due to flow restriction in the waterway, these problems are rarely improve due to lack of space and land. With back pressure control systems, such waterway water flow restriction the problem can be solved. Technically, there are areas that experienced past flooding situation, but drainage enlargement improvement works were done, and such waterway should have spare capacity after water restrictive flow condition is removed by the back pressure control system.

OBJECTIVE

[023] To alleviate flooding condition, the present solution aims to manage water flow with coordinated implements to generate back pressure along the water flow system.

Beyond Flood Alleviation

[024] Beyond the objective to alleviate flood, the need to maximize the drainage functioning capacity and to increase reservoir storage capacity in any limited land environment is a challenge. Generally, drainage systems are inter-connected and discharge water to a single waterbody at its terminal end. This waterbody can be a reservoir, lake, river or sea.

[025] With a new Dry-Drain System (DDS) we can overcome the exit discharge flow restriction due to the water level of the terminal water body. This DDS is to maximize the overall drainage hydraulic gradient and also to improve discharge efficiency in the drainage system. The DDS discharge water from the drainage network by water pump, the water can be transfer to height to an elevated reservoir without affecting by the drainage discharge restriction at lower stream. The same water discharge handling system also can be utilised for secondary application or discharge to a new waterway to discharge water to support or increase the existing waterway capacity as a new waterway is the further extension of the current waterway

[026] With a Double-Deck-Reservoir System (DDRS), as the elevated waterway is built above the existing water channel air space, we open up the option to increase water storage and raise water storage level in the existing reservoir by utilising air-space over the existing reservoirs to expand reservoir capacity. When this is done, we can store more water over the island with less land. With the open-air space and water pumps, we can arrange to store our rainwater at height by stacking up multiple interconnected water holding tanks on structure over the existing reservoir. This is a new option to store our green water instead of discharging it to the sea.

[027] This green water conserves the recycled electric pump input energy as potential energy for further usage on many potential applications. This combined water management to store more water, to maximize water flow also to alleviate flood. By preventing flood, it prevents material lost and prevent lost to productivity and save cost on post flood condition recovery, this is an act in making earth greener before wastage and prevent productivity losses during every flooding occurrence.

[028] A Transfer pump is a critical set of equipment to both DDS and DDRS to functions. A single set of pumps is only required to serve both systems in a common Transfer Pump House/Building. The choice of pump house location is critical, it has to be close to the water channel and the reservoir, it can be partially over the water surface and land. The electrical energy used to operate the pump is converted as potential energy as high level water storage reservoir water waiting for further application.

[029] This is a 'Green' process with lots of saving on its multiple secondary function applications without added electrical energy use.

[030] On our existing reservoirs, technically, there is a water depth limit for healthy fresh water storage. When the drainage discharge end is isolated from the reservoir water, the DDS in-built water pump function can deliver water to the raised water level storage to increase storage capacity and also to improve its water circulation to the increased water depth to the current reservoir. This added water circulation function is to prevent stagnant water storage condition due to increased water storage depth

[031] In most occasion, to increase the existing upstream fresh water reservoir water depth and its holding capacity, we only need to raise the lower section of reservoir perimeter boundary wall. This raise of the reservoir water level leads to increase the total national reservoir fresh water storage capacity without additional land use.

[032] With the DDS & DDRS we can build new higher water level reservoir to increase the current reservoir storage through increase water depth. How much more water we can hold if we were to raise all our reservoirs water surface area by just one metre of additional water?

[033] With a new Water Highway Canal, we can increase the lower stream channel capacity after transferring upper stream channel water separately out to the Water Highway to the reservoir without flowing through the lower stream channel.

[034] The conversion of mid or/and lower section of waterway air space to a new Water Highway Canal to discharge water directly to reservoir and away from its lower stream channel, this relieves the lower stream drainage loading and also relieve the ponding and flooding potential and also creating potential to expand the reservoir capacity. We can have multiple Transfer pump stations serving a common Water Highway Canal.

[035] In combination with the Back-Pressure-Control System, Dry-Drain System, Double-Deck-Reservoir System and Water Highway Canal, we improve the current waterway flow system and increase its water holding capacity, increase reservoir storage without additional land use and add value to current water surfaces for additional functions. It also changes our thinking on future water resources relates to possibilities and to create better land use.

SUMMARY OF INVENTION

[036] The Back-Pressure Control system (BPCS) for open water channel to alleviate water ponding and flood conditions.

[037] The Dry-Drain System (DDS) to maximize drainage flow function with ability to 'Zero' terminal exit discharge restriction.

[038] The Double-Deck Reservoir System (DDRS) to maximize reservoir storage capacity and recycle its potential energy.

[039] Water Highway Canal (WHC) to maximize water channel capacity and function with no additional land use

BRIEF DESCRIPTION OF DRAWINGS

[040] FIG 1A-1E: Various flow improvement means such as teat bump, channel divider, crescent vane, holding gate, confluence channel divider and duplex holding gate vane.

[041] FIG 2A-2E: Various designs of holding gate.

[042] FIG 3A-3E: Various modes of application and installation of gate vane.

[043] FIG 3: The Dry-Drain System is a practical function to overcome the as built waterway condition and its flooding problem. It is a solution to overcome the land limitation with multiple possibilities to recycle the used energy by installing infrastructure for water recycle productive uses. It also opens the waterway land for multiple constructive usage and functions beyond economic value. A preferred embodiment of a dry drain system that empties to the sea

Back-Pressure Control System (BPCS)

[044] This invention relates to the application of Back Pressure Control Fixtures (BPCF) to manage/control the dynamic of back pressure water flow and its water level to alleviate potential flooding in urban open channel. This is a control system on flow restriction also to maximise the as built drainage network functioning capacity to perform under all extreme rainfall input conditions.

[045] The BPCF works to minimise unbalance water flow pressure and its potential energy by Improving crossflow, back flow conditions through localised flow separation, guided flow passages to generate streamline flow without creating flow collision and restriction.

[046] The BPCF improves the transient water flow level and pressure through diverting/holding water in the existing water channel. The system also able to hold a larger volume of transient water in selected upstream channel without alteration to the channel section.

[047] In any open channel drainage network, there are sections of drainage with capacity which are not fully utilised, but at the same moment there are overflow flooding in the close-by network drainage. When the water in the channel can be better distributed, most of the flooding condition could be alleviated. This is a control system to manage the water flow with simple fixtures to neutralise the back flow energy without refixing the drainage.

[048] The function of BPCS is similar to the traffic lights and filter lane in the road traffic system

The Back Pressure Control Fixtures (BPCF)

[049] The BPCF is designed using a variety of fixtures including and not limited to Teat-Bump 10, Channel Divider 20, Duplex Holding-Gate-Vane 40, Confluence Divider 60 and Holding-Gate 30 as illustrated in FIGs 1A-3E. These are fixtures design to streamlines, divert and hold water flow to prevent formation of flow colliding energy to cause flow restriction without making changes to the general channel structure/layout.

[050] The Holding Gate 30 is designed to hold water with its potential energy to manage upstream water holding/discharge. It held upstream water through restrictive flow design at the same time to discharge water to downstream to the required level to enhance streamline flow. These fixtures are designed to fit channel structure without complete closing the waterway, it is not to shut the water flow and also not to hold up debris. It also managed water level on both upstream and downstream.

[051] The combined capabilities of these fixtures also enable control on discharging/retaining of the potential energy of the retained water. With this management of flow energy, we are able to manage the relative water level at its up and down streams water flow condition.

[052] With suitable application of simple Holding Gate 30 or in the form of Duplex Holding Gate Vane 40, we can maximize water holding in suitable section of upstream waterway when there is spare waterway capacity to hold storm water. This in effect is to increase our national total storm water holding capacity without addition land use.

[053] The BPCF can be applied individually or collectively to manage the Back-flow water energy. It functions to induced or deflect reactive back pressure energy to smoothen flow or streamline discharge.

[054] The combined application of Gate Vanes of various designs can be organised to streamline water flow and its flow energy toward an overall smoother and lower flow water level. It also can function to hold upstream water with its potential energy to improve down-stream water flow condition and delay discharge and function like a stormwater tank but with lower energy continuous water discharge.

Teat-Bump (TB)

[055] The Teat-Bump 10, TB is to convert straight edge merging sharp turn to a top view teat sectional profile to merge the water flow gradually to streamline flow on the merging corner junction with gradual diversion to reduced colliding energy. It is applicable to all the confluence upstream turning, downstream turning corners and also applicable for any inward sharp turning corner along the waterway.

Crescent-Vane (CV)

[056] The Crescent-Vane 50, CV is a curved profile vane to streamline water flow to convert any sharp inward turning corner to smoothen water flow within the channel passage.

Confluence Channel-Divider (CCD)

[057] The Confluence-Channel-Divider 60, CCD is a streamline flow device to separate the merging flow water and to realign these flows to the common discharge direction without forming colliding flow. The CCD arrangement changes the confluence merging flow by reducing the flow energy losses in the usual open junction flow to convert the stagnation zone and separation zone to positively aligned the water flow energy with reduced turbulence.

Channel-Divider (CD)

[058] The Channel-Divider 20, CD is a profile vane channel to split the channel water flow cross-section inline to the waterflow to reduce the formation of cross flow or turbulence flow at sharp turning bent. It can be applied to streamline flows at sharp turning channel, sudden change of channel base elevation at a merging flow, or any sudden change of channel section profile or merging flow.

Holding Gate (HG)

[059] The Holding-Gate 30 design is a partial restrictive flow gate to hold transient water through back flow energy. This is in effect managing /delaying the water flow with its potential energy within the passageway. The HG is a partial cover gate mounting across the channel width with a bottom gap and top overflow opening. The bottom gap opening determines the relative pressure leak to the holding water level / depth. A plurality of gaps across may be provided across the width of the gate. Vertical adjustment of the gate panel position by sliding vertically along guide grooves on opposing wall mounts allows more high pressure water to exit between the base of the channel and gate, thus changing the holding water level.

[060] The primary function of HG 30 is to delay water down-flow and retain its potential energy. To hold large amount of water/energy, it is best to apply multiple gates along the upstream channel rather than a single piece of larger cross-sectional area gate. This holding of water in upstream channel sections acts as a functioning storm water storage drainage section.

[061] The additional functions and designs as shown in Holding X Gate 70 are to manage the overflow water to meet downstream channel layout to streamline the merging flow condition. The HG is also designed to improve debris discharge to suit the existing drainage condition. The gate panel openings notch can be at the top, bottom of left or right or centre position to fit channel condition and minimise debris collection.

[062] The general basic effective gate surface area is about 30% to 50% channel section opening area or the channel depth. With its profile openings at lower bottom edge and upper top edges, it should be positioned to hold water to a safe water level to about 80-90 % of channel height at historical known heavy rainfall without causing flood or accumulating debris. To determine the ultimate, maximum safe water holding level to the HG after installation, it should be able to prorate from a known extreme heavy rainfall water input and its corresponding water level condition.

[063] The gate active surface area and when the gate is at its lowest/minimal opening position is to predetermine the water level potential upper limit due to the backflow energy generation. When this pre-set upper safety limit size gate is elevated, it lowers the backflow energy due to the release of the higher-pressured energy at the bottom of the channel, thus it releases more energy and leading to a lowering of holding water level.

[064] The adjustment of the gate elevation also changes the overflow and underflow ratio to micromanage water level condition.

[065] The optimum functioning gate surface area is specific to its relative location and subject to the potential catchment maximum rainfall water input.

[066] The gate elevation operation can be designed either by auto-floatation adjustment relative to water level, or powered controlled, or manually positioned.

[067] Under the same holding water level, the same profile gate position with larger bottom opening generates lower back flow pressure to hold water. This higher gate position releases more energy/pressure to lower the upstream water level. Any gate position lowering is to reduce the bottom opening will result to increase in back flow pressure and to increase upstream water level and its overflow. This is due to differential water pressure changes along with the depth of the stream.

[068] The Holding X Gate (HXG) 70 is designed to neutralise the top-down overflow water energy to smoothen the water down flow. It is best to combine a bottom inverted 'V' and a 'U' upturn flatten crescent opening at the top centre of the gate. Various permutations of the shape and placement of the bottom opening of Holding X Gate 70 are possible as illustrated in FIGs 2A – 2E. As seen between FIG 2A and FIG 2B, the upper edge of Holding X Gate 70 may also be varied. The combined top opening and bottom inverted V as illustrated in FIG 2B produces the best water streamline flow result under high water flow pressure.

[069] In the drainage system, any flow restriction section induces flood can be corrected by holding its upstream water, by shifting flow pressure and transient water to upper section to lower the flow pressure at downstream to manage streamline flow to fit lower stream opening or physical structural restriction

Duplex Holding Gate-Vane (DHGV)

[070] The Duplex Holding Gate-Vane 40 is a HG and a GV in combination with a common basic dimension to the drainage base / wall. This integrated Holding Gate and Gate Vane is to hold water and its flow energy, the Gate-Vane releases water through the profiled Vane to initiate streamline downstream water flow and to avoid potential colliding flow by holding part of the upstream potential energy.

[071] The GV is located at the base of the gate, and the HG is design to position/move upward relative to the GV and the base. This relative movement is design to increase or decrease the holding /overflowing function.

Float Gate-Vane (FGV)

[072] The FGV is a water level activated gate-vane. It is designed with buoyancy to function only relative to certain water level. It is auto return to a stored position when at rest by gravity when water level subsided.

[073] The gate is only function to direct water flow with directional vane gate to manage high level water energy. It can prioritize flow to support confluence or along channel section.

[074] With the combined application of the HG & other fixtures, we can delay water congregation at the sections of the network with serious flooding issues, for example sections with down-ward flow physical restriction, such as passage underbridge or complex confluences arrangement with steep elevation changes.

[075] At any identifiable critical location, we have options to manage to lower water level, streamline water flow or to divert water flow. We can avoid water congregation at the most undesirable location by holding water at selected upstream channel section with spare channel capacity to function as a transient storm water storage section.

Basic Flow-Control Fixtures (BFCF)

[076] The Basic Flow Control Fixtures (BFCF) of a BPCF consists of flow improvements means including Teat-Bump(s) 10, Crescent Vane(s) 50, Channel Divider(s) 20, Confluence-Channel-Divider(s) 60 and controllable flow control means such as Holding Gate(s) 30. A combination of these fixtures improve water flow condition to all areas of common basic weaknesses in drainage layout or the drainage profile flow restriction, it can be installed through observation and understanding of potential flow restriction condition irrespective of water flow input condition. Other designs of controllable flow control means including Duplex Holding Gate-Vane 40, Holding X Gate 70 may be used as appropriate.

[077] This water flow model tested basic starter fixture set is suitable for installation in all the major waterway in the urban flood prone catchment area and its major downstream water way to lower water level through streamlining and reconditioning the waterway water flow all the way to its exit discharge.

Secondary Flow-Control Fixture (SFCF)

[078] The Secondary Flow Control Fixture (SFCF) of a BPCF is for additional water flow intervention after the BFCF streamline flow improvement. The SFCF consists of flow improvement means as well as controllable flow control means such as Channel-Divider (CD) 20, Gate-Vane (GV), Holding-Gate (HG) 30, Holding X Gate (HXG) 70 and Duplex Holding-Gate Vane 40.

[079] A macro view and assessment are required after installation of the BFCF corrective intervention. The SFCF is customised to further reduce the turbulent flow condition plus divert and hold/delay the water to lower the overall water flow level. With the addition of BPCF Fixtures in the current waterway, we should be able to better condition the overall water flow level in water channel with almost no alteration to the drainage network. This achievement is by streamlining water flow along water passage, preventing flow collision, diverting flow or hold water with its water potential energy.

The BPCF Design, Application and Installation (D, A, I) of Gate Vanes (GV)

[080] D&A: The Gate-vane is a partially restrictive flow barrier panel structure to install within the waterway. It is not a shutdown gate to completely stop water flow.

[081] D, A & I: Gate-Vane 80 is positioned and arranged in the channel, customised to the channel profile & structure. In various embodiments, Gate-Vane 80 can be designed for angular rotation along an axis generally vertical to the length of the channel, in other embodiments, Gate-Vane 80 can be arranged to rotate in an angular direction transverse to the water flow or other variable adjustable angular positions to fit its functional needs as fixed or flex relative to water flow energy.

[082] D & A: Gate-Vane 80 design has a 3-D profile rigid panel. The 3-D profile rigid panel has an optional extended flexing panel or material at trailing end to extend water flow energy conformation to better streamline flow.

[083] A & I: Gate-Vane 80 can be positioned at any section of water way along the water channel.

[084] D & A: Gate-Vane 80 can be positioned in any part of the channel cross-section with an effective surface area relative to channel sectional opening area. This act to induce effective water flow control or water holding control without closing the channel passage.

[085] D & I: Mounting of Gate-Vane 80 can be achieved by anchoring to a vertical/horizontal support hinge, on beam or pole, on channel wall as illustrated in FIG 3A by a wall mounted zipper design for larger/lighter gate mounting with higher alignment tolerances, FIG 3B wall mount is adapted for a simple gate 80 to be installed in a channel with rigid solid wall structure, FIG 3D wall mount is adapted for higher water flow velocity. Channel base as depicted in FIG 3C, or channel top as shown in FIG 3E or in any combination of above mounts may be used in current channel structure without changes its physical dimensions. The optional extendable flexing pane is shown in FIG 3D. For FIGS 3A to 3D, the gate 80 rotates about a generally vertical axis. Gate-Vane 80 of FIG 3E rotates about in a horizontal axis.

[086] D, A & I: Rigid horizontal swing Gate-Vane 80 as shown in FIG 3D may be provided with a flexible tail end to neutralise/ manage complex directional water flow of high velocity (to auto swing to position by the water flow forces to streamline the water flow and deflecting upstream flow while inducing minimal back flow energy).

[087] D & A: Gate-Vane 80 can be activated/ positioned by water flow energy or/and floatation energy and/or function relative to water level.

[088] D, A & I: Remote-controlled powered Gate-Vanes 80 can be driven/ position by hoist/winch, powered actuator, or motor through pneumatic power, electric power or hydraulic power.

[089] D, A & I: All Gate-Vanes 80 are designed to prevent debris holding at the channel bottom base or its channel wall with debris passages opening at the base or gap to the wall.

[090] D, A & I: Referring to Fig 3C, vertical rotating Gate-Vane 80 is pivoted about a single rotating axis and can be actuated to a variety of positions with corresponding effects on flow direction. This single structure comprising 2, 3 or more axially radial vanes are not limited in shape or profile of the vanes to generate the back flow energy while directing greater downward flow to either side of channel wall possibility as needed. For instance, it can create more back flow energy on one side of channel flow while creating streamline flow on the other side.

[091] A & I: Gate-Vane 80 can function as a stand-alone unit or operate in series with multiple units to function collectively.

[092] D, A & I: Gate-Vane 80 is designed to fit the current drainage channel structure/dimension with option or also to fit altered channel structure / dimension.

[093] D, A & I: Powered Driven Gate-Vane 80 can be of electrical, pneumatic, hydraulic driven with remote sensing and control.

THE Dry-Drain System (DDS)

[094] The Dry-Drain System 90 is an urban drainage network with 'water transferring pump system as its discharge terminal end. This water pumping system is arranged to discharge the water in the water channel to 'Zero' water level if it is needed.

[095] A usual terminal discharge end of a drainage system is connecting to a reservoir, lake, river or sea. The water level of this connecting terminal water body preloads the initial drainage water level and it reduces the functional flow capacity in drainage system. The Dry-Drain System is to maximize drainage network discharge functioning capability with a terminal pit and discharge transfer pumps.

[096] The lowering of the channel terminal end water level to minimal or "zero off", is to remove this preload water and its potential flow restriction in the current waterway. This "zero off" the terminal water level maximises the drainage layout functioning potential and adds value to prevent flood.

[097] Technically, the drain can be kept dry to anticipate for the next potential rain storm. It can also maintain or add more ABC water features to green and beautify the neighbourhood with more activity space on the pathway or platform over clean waterway. With the transfer pump, there is a functioning potential to increase the receiving reservoir capacity to a higher water level beside maximizing the drainage function.

Potential Benefits of DDS

[098] The Transfer Pump House 'TPH' is the key addition to the Dry-Drain System. The TPH can add tremendous value to land use, it combined land utilisation over water surface, it houses over bridges and waterways. When we combine the nearby waterway land reserve, water surface area over waterway and reservoir and connect to the nearby open land space, this TPH can be a very interesting building with design and functions, as the limit is only by our imagination.

[099] The TPH is not only to house the pumps but also enable to remove debris efficiently and filter the drain water before transfer to reservoir. Through the mechanised and automated process, we also remove the current unsightly debris floater holding in the current waterway.

[0100] The TPH can be a composite complex with functional connection across the waterway for human and motor vehicles. It can be a large open space area for community activity and event. It can be a shopping mall with hotel with activity space for creative function and event hall for conferences.

[0101] With potential planning on basement connection to MRT and bus interchange nearby with parking facility, it shall be a centre place for social activities for gathering with high human traffic.

[0102] With the above, the Transfer Pump House shall be a Transfer Pump Complex (TPC) to finance and maintain the added waterway water pumping function and also to upkeep the expanded reservoir.

[0103] When the Transfer Pump Complex is built with water features, its design can add "free" water flow element with multiple different water related functions as part of the building complex, the multiple water functions add significant economic value without additional energy input to the building by DDRS (Double Deck Reservoir System). This DDRS is design to store more water while retaining its potential energy to creates potential economic value. This TPC can be the landmark building to the neighbourhood.

[0104] With the water transfer pump, water can be transfer to the elevated reservoir. We can relook at our current reservoir storage water level. We can raise reservoir water level while improving the waterway capacity without making changes to the waterway. We can have secondary levelled reservoirs position in the current reservoir air space, we expand our water storage capacity without addition land utilisation. After the pump and filtration process, the water discharge passages can start from multiple large light weight precast interconnected tanks. The design of such tanks should be made in factory and transfer to site to arrange to lift onto superstructure over the

reservoir. This storage water can be used for water landscape features, waterfall like features, fish ponds, plant irrigation, automatic water flushing for cleaning and washing on general area maintenance function etc.

[0105] On top of all the potential positive functions above, the two main functions of the Transfer pump shall remain as to lower the waterway water level at its peak flow, beside it also functions to convert the waterway water to reservoir water and to upkeep a healthy quality water in the enlarge reservoir capacity by a deepened reservoir.

Double-Deck Reservoir System (DDRS)

[0106] When the water in the channel is transferred to a higher-level reservoir through the Dry-Drain system, it can retransfer the water through gravity flow for any productive function or other lower-level reservoir through control valve or by overflow.

[0107] This single stage water transfer from multiple interconnected reservoirs on stacking with secondary water transfer capability without further power input but utilise the stored energy by gravity flow with bottom drain-off valve /gate or overflow is a Double-Deck-Reservoir System.

[0108] This arrangement can increase the current reservoir storage capacity without additional land use. It also serves as a potential energy bank waiting for many potential green applications/ functions. It is best to use the DDRS system in combination with the 'Dry-Drain System' as we are saving energy by transferring the water only once with water pump.

[0109] The concept of stacking up water reservoirs is to create more water storage capacity over air space or over existing water surface. Technically we can use the elevated reservoir tank water to support the green elevated farming or industries at the selected reservoir neighbouring area to create potential for other innovative applications.

[0110] The DDS and DDRS can convert valuable air/land space for many cities green farming industries, community activity or commercial related to water activities.

Water-Highway Canal (WHC)

[0111] The Water-Highway Canal is an elevated canal over existing waterway system. When an additional elevated water canal is built over the existing waterway from its upper midstream or any

other section of waterway to transfer water flow directly to reservoir bypassing the lower stream waterway, this is an added water discharge capacity over the original waterway. This added capacity discharge passage is free from the lower stream tributaries flow interruption, thus the discharge at the overall drainage system will have smoother discharge of higher capacity which only require a single much smaller cross-section waterway profile.

[0112] This arrangement is only makes possible by Dry-Drain System to transfer water to higher level WHC for further discharge to reservoir or any storage destination. The line of columns supported WHC upturn beam of U-section design can be a single or multiple channel waterway with potential use for other function like pedestrian walkway above waterway, lower level and higher-level jogging way.

[0113] Generally, there are 3 major elevation levels sections to overcome any obstacles. The lowest level is at the ground level but above the downstream main waterway to discharge to the Reservoir or to another TPH for further transfer. When the WHC encounter bridge or any obstacles, the water can flow downward under then up with one or multiple U shape conceal pipe crossing below the bridge or obstacle. This U pipe reconnect to the new section of the water highway with its raised opening exit opening level at lower than U pipe entry level.

[0114] There shall be design opening for maintenance purpose, and small opening for drain-off stagnant water to keep Pipe dry.

Smart Drainage System

[0115] With variable power drive attachment, the powered actuated Gate-Vane can be managed from remote to meet live sensor feedbacks on the changing water flow condition with safe corrective action. Overtime, when sufficient data is available on water level, water flow pressure and rain fall condition, the system is possible to adapt to AI management with weather forecast input.

The water flow pressure and water level

[0116] The management of flash flood problem should be an ongoing task like road traffic management system. Currently, water flow in waterway is conditioned after drainage is built. We let

the water flow without any control or management along its flow passages. With the unpredictable water input weather condition and the rain eater input, we receive rainwater as is where is fall.

[0117] In urban open channel drainage system, there are many confluences within a drainage network, these repeating confluences, and its unbalanced merging turbulent flow resulted in delaying its water flow. Such repeated water flow restriction elevates the water level to most of the channel sections beside the flood prone area. Under such condition, region with same water level but with higher water pressure is likely be the potential flood prone locations.

[0118] Water flow in channel is always subjected to multiple forces beside the upstream water input and its other hydraulic forces. For water level to rise, it must go through a series of accumulated substantial water pressure increases. The time taken to accumulate such increase in water flow pressure is a leading indicator to higher water level and it eventually resulted to flood.

[0119] If system is built to collect such data on water flow level and its corresponding flow pressure, such data can be form as a flood warning indicator to direct a corrective action to prevent flood for this particular location.

[0120] Water Level & Water Pressure Monitor System

[0121] Within a catchment area, the open channel drainage discharge system flow is always subject to water input to its various locations. Sometime, rainfall may cover the whole catchment area, but most time, it just passing on to other catchment area.

[0122] The potential maximum water input level for a particular catchment area should be the highest historical recorded water received over the whole catchment area. In any condition, when this drainage system is filled with water, we can monitor its water pressure and its corresponding water level during its discharging stage. The water flow pressure and its water level should be the indication of the condition of water flow for the particular section of channel.

[0123] During a lasting rainfall of almost constant input within a common catchment area, all the percentage differences on water level in the drainage sections within the same network should also remain relatively constant if there are changes in rainwater input.

[0124] When there is an increase in water input, there should be a corresponding change to its flow pressure first then only follow by water level change from section to section of drainage until its input flow is stabilized. In any water filled channel, the water pressure changes are always ahead of

water level adjustment. This is due to the water pressure condition is related to the water flow condition. A non-streamline flow meeting a high backflow energy is sure to raise the water level at the encountering location. This peak flow crest condition require time to stabilise. A non-restrictive streamline flow is a lower water level flow.

[0125] Over time, through a period of recorded data, we can establish the dangerous water level and its corresponding pressure at certain section of channel. With the established danger water level, we can set standard operation procedure to lower the increasing water pressure before the rising water level. The water flow pressure build up is always ahead of the rising of water level.

[0126] This delay process enables us with lead time to improve the drainage function with safer margin to prevent flood.

[0127] When the live rainfall input in various catchment areas is available, the live information provides us the potential rainwater input to the channel network. If we can also monitor the channel water lever and its relative live water flow pressure, then we can identify the particular section of current drainage functioning weakness, at its corresponding water level in the water channel.

[0128] With the ability to measure multiple catchment areas, we can improve the overall water flow in the connecting major discharge waterways for the larger area of multiple catchment areas which are link to the common discharge terminal reservoir, river or sea.

[0129] With the available data, we can safely plan to maximize the water discharge flow without causing overflow in certain section of waterway or to design to withhold water for drainage performance improvement.

[0130] On future live automatic activation or human managing system implementation, we can plan for longer time data collection and ultimately functions on AI management.

[0131] To maximise the drainage holding and effective discharge rate, multiple Gate-Vanes is a better option as compared to a single, large Gate-Vane to manage a longer section of channel flow passage.

An Ideal drainage system with constant water flow pressure at all waterway section.

[0132] Due to our physical land restriction, when there is no possibility to increase the current physical drainage dimension, we should manage water level in the waterway by diverting water away from problem flood zone to other section of channel with higher channel wall.

[0133] Most flood condition is due to the existing physical drainage network layout induces unbalanced flow pressure leading to flow restriction under various different extreme rainwater inputs.

[0134] An AI live monitoring system on water flow level and its corresponding water flow pressure with the corresponding rainfall input in the particular drainage network catchment area shall be basic requirement to control water flow level to the optimal flow potential for multiple connecting channel network.

[0135] With the above live information and the Auto remote control Gate-Vane application, the objective precision intervention and conversion of the transient energy through installation of remote-control Powered Gate-vanes, we can maximize our drainage capacity without further enlarging drainage to achieve a no flood condition.

[0136] With the collected data as reference, we can set critical control limit to activate corrective intervention. Over time such data can be program for planned management to maximise the drainage water flow, and also for transient water storage holding with safety limit control. With AI application under all form of rainfall conditions, the system can be applied to a larger drainage system.

[0137] The control of Back-flow energy is to manage the transient water flow level and it is in effect holding the water at upper stream drainage sections which has spare water holding capacity. It can act to lower the water level at the low drainage wall section by reducing flow restriction to prevent flooding.

[0138] The combined application of Gate-vanes can increase the transient water holding capacity within the whole drainage system. This increment of transient water holding capacity is an increase to the existing storm water storage system capacity. It is an addition to the current storm water tank program.

[0139] Overtime, we can convert certain Stormwater tank for other productive usage as these tanks may not relevant to prevent flood anymore.

[0140] To maximise the potential capacity of existing channel drainage system, we need to monitor its transient water flow pressure and water flow level at all the major confluences. The passages nearer to common flood prone sections are the initial area to start the network water flow management work.

[0141] The indicative data on water level and its corresponding pressure can be the answer to the solution to the flood alleviation and also to improve the overall flow condition. When the corrective flow balancing of all the key locations point is made possible, we are almost maximising the water discharge potential functioning capacity.

5 Channels 4 confluences-Water Flow Model Simulation Flow Tests

[0142] This is a constant volume, constant hydrostatic water input condition Flow Simulation Model.

[0143] The constant volume input water is distributed to each of the 5 channel to simulate rainfall water input to the 5 respective watershed areas. The water flow through a right-angle turning corner in each channel to its confluence connecting to the main discharge channel.

[0144] After accumulating water from the 4 confluences into the common main stream discharge channel, the water flow terminates to an outlet opening with variable discharge conditions design to simulate different receiving end waterbody such as reservoir, river, lake or sea.

[0145] The total water input or the total discharge simulate the total rainfall collected on a larger combined five catchments areas.

[0146] The model simulates the common channel design with sharp turning corners and confluences which generate flow restriction in the drainage system. The five channels model provides an overview to all water flow levels to differentiate water level under condition on free flow vs-controlled flow.

[0147] The variable water input ratio arrangement is to simulate rainfall changes to various catchment area. The merging flow discharge end exit is design to simulate 3 different discharge opening arrangement setup. The discharge end is set up with free flow discharge and dam up discharge. The latter is to simulate the water level at the connecting discharged end waterbody. The

three opening conditions is to simulate the variation on backflow energy and it resulted to different water level changes to the network system. One of three above discharged opening is designed to simulate a condition where there is an additional backflow pressure from an imaginary downstream connecting waterway network after the exit gate to the current flow test model set up.

[0148] The flow test also simulate water back flow effect to any channel catchment which is receiving 'No water input' or 'no rainfall' but water level in this particular channel remains high due to back pressure induce backflow water and water level subsided to lower level in corresponding to BCF installation.

[0149] To simplify flow test, a set of Basic Flow Control Fixtures (BFCF) is selected for the flow performance test run. The BFCF can generally be apply to the drainage network to improve flow condition and with minimal risk of inducing flood. This is to say that with no change or without additional interference to the general drainage network, we can lower the water flow level through BFCF addition to the network.

[0150] Under various water input-mix ratio conditions, and all the discharge end set up possibilities, the result shows the consistency in water level improvement after addition of Flow Control Fixtures. As the flow model is to simulate water flow condition, it is built with common water flow design features like sharp turning corners and confluences.

[0151] Comparing the water levels under free flow condition to the control flow with addition of Basic Flow Control Fixtures, the flow intervention shown positive result in lowering the water flow level consistently under various water input mix and exit flow conditions. Generally, it shows higher percentage improvement and coverage in more locations under high-level flow water. The water level improvement is due to the back pressure energy element is reduced or neutralised with addition of BCF.

Flow Simulation - Free Flow Vs Intervention Flow with Basic Flow Control Fixtures

[0152] The flow test compares water flow network under Free Flow vs Control Flow

[0153] To simulate the different flow conditions in a common water network, there are six 6 different water flow intervention parameters setting for comparative performance.

[0154] These are two, 2 different exit water level condition setups together with another three, 3 different channel exit opening arrangement conditions. All these 6 conditions generate different restrictive back flow energy

[0155] In Test run # 1, there were 23, designated monitor locations within the water network, we observed the water flow level and make comparison on it changes under different simulated flow condition. To complete a full set of comparison test run under one water input condition.

[0156] There are 23 X 6, data for Free flow and another similar amount of data for controlled run. To make data comparative measurement, there are $2 \times 23 \times 6 = 276$ data in 6 different exits flow set up conditions.

[0157] The observed water level differences with respect to the free flow condition were then converted to percentage differences for each monitor location.

[0158] The dam up water level and the exit opening arrangement at channel exit end is to simulate the terminal end waterbody water level and its back flow energy generation simulation.

[0159] With multiple extreme different water input ratio mixes flow test conditions, the managed Back-Pressure Control System with the Basic Flow Control Fixtures demonstrated very positive result on water level changes on maintaining / lowering water level improvement to lower the channel water under all exit conditions, almost 100%* of the 23 locations within all the 5 channels.

[0160] The percentage water level lowering at any monitoring location is subject to different water input ratio condition and the exit discharge condition. The test shows better result at Higher induced back pressure energy condition result to higher percentage improvement.

[0161] The similar result also shown on Test run # 2, 4 channels and 22 basic monitor locations were measured. On Test run #3, all the 5 channels with 27 monitor locations reading were measured.

[0162] Comparative flow test #1 were performed with Basic Flow Control Fixtures (BFCF) in the water flow model network system with 50 percent of water input into a single channel and balance of water distribution at 12.5 percent of water in each of the 4 remaining channels. The major water channel is either arranged to set at Upstream, Midstream or Lower Midstream. The total 3 x 138 sets of comparative data in percentage for 3 water input conditions are as follow.

TEST RUN CONDITIONS on #1, #2, #3,

Similar set up conditions on all comparative runs.

- 1, Constant volume input, Constant Hydrostatic flow.
- 2, Same monitor locations in the channels to monitor water flow level changes.
- 3, Same placement set up and control kit fixture arrangement.
- 4, Same set of BFCF Basic Flow Control Fixtures
- 5, Under same common input on same exit water level and exit opening conditions
- 6, Same common drainage design with the same as built imperfect conditions.
- 7, Data recording by same person from the same fixed in position with thin steel rulers measuring gauge.
- 8, Potential human reading error interpretation error + /- 1 mm.

[0163] Similar comparison on each different water input mix set up.

- 1, Comparison for Free Flow vs BFCF Interfere condition
- 2, To compare flows under 3 different exit opening designs condition.
- 3, To compare flows under 2 different exit water flow level condition.

* Similar comparison for # 2 Vs # 3 after # 3 is one HG less.

* The HG @ lower stream on # 2 is excluded from channel

Comparative Test run # 1

with Extreme water input mix

Free Flow Vs Intervention Flow with Basic Control Fixtures

Simulated test run with 5 X 2 Holding Gates & in Extreme Water Input distribution.

23 Monitor locations

50 percentage water input to one single channel.

Repeat Comparative Test Runs for Up-Stream (US), Mid-Stream (MS) or Lower Mid-Stream (LMS).

The Balanced water is equally distributed to the 4-remaining channel

50% Water Input @	US	MS	LMS	Total Test Measurements	US	MS	LMS	Total Test Percentage
Water Level Changes	Number Of Measurements				% As to 138 data			
Positive Lowered	85	96	94	275	62	70	68	66
Positive Equal	15	6	4	25	11	4	3	6
Positive Higher *	36	36	36	108	26	26	26	26
Negative Higher **	2	0	4	6	1	0	3	2
	138	138	138	414	100	100	100	100

*Water level increase at Upstream of the Holding Gate is expected.

**Monitor location is too near to the HG under this water flow condition

23 data on 23 monitor locations on each flow test run

23 X 6 = 138 data on each water input under 2 exit water level and 3 exit condition @each run.

138 X 2 = 276 data on a comparative test run @ 50% water input to A single Channel.

276 X 3 = 828 data on 3 set of comparative test run set with 50% water input to a single channel.

Comparative Test run # 2

with NO water input to 1 channel & equal input to 4 channels

Free Flow Vs Intervention Flow with Basic Control Fixtures

Simulated test run with 5 X 2 Holding Gates

22 Monitor locations

One single channel with No water input.

Equal water input to 4 balanced channels @ 25% each water input.

Repeat comparative test run with No water input to US, MS, LMS, LS, channels.

No Water Input @	US	MS	LM S	LS	Total Test Measurements	US	MS	LM S	LS	Total Test Percentage
Water Level Changes	Number Of Measurements					% As to 132 data				
Positive Lowered	92	96	94	84	366	70	73	71	64	69
Positive Equal	11	11	14	24	60	8	8	11	18	11
Positive Higher *	27	24	24	24	99	20	18	18	18	19
Negative Higher **	2	1	0	0	3	2	1	0	0	1
	132	132	132	132	528	100	100	100	100	100

*Water level increase at Upstream of Holding Gate is expected.

**Monitor location is too near to the HG under this water flow condition

22 data on 22 monitor locations on each flow test run

22 X 6 = 132 data on 2 exit water levels X 3 exit condition @ each 0 or No water input run.

132 X 2 = 264 data on each comparative test run @ No water input to a single channel.

264 X 4 = 1056 data on 4 sets of comparative tests run with No water input to a single channel.

Comparative Test run # 3

similar to Test run # 2 with reduced Holding Gates

Free Flow Vs Intervention Flow with Basic Control Fixtures

Similar Simulated test run as per # 2 with only 5 X 1 Holding Gate,

27 Monitor locations.

Maintained 5 upper Holding Gates but removed 5 lower Holding Gates.

Equal water input @ 25% each to 4 channels, and No water input to a single channel.

Repeat and Rotate test run after complete each set of No water channel runs.

No Water Input @	US	UMS	MS	LMS	LS	Total Test Measurements	US	UMS	MS	LMS	LS	Total Test Percentage
Water Level Changes	Number Of Measurements						% As to 162 data					
Positive Lowered	125	124	100	104	113	566	77	77	62	64	70	70
Positive Equal	34	28	39	53	46	200	21	17	24	33	28	25
Positive Higher *	3	9	16	5	3	36	2	6	10	3	2	4
Negative Higher**	0	1	7	0	0	8	0	1	4	0	0	1
	162	162	162	162	162	810	100	100	100	100	100	100

*Water level increase at Upstream of Holding Gate is expected.

**Monitor location is too near to the HG under this water flow condition.

27 data on 27 monitor locations on each flow test run

27 X 6 = 162 data on 2 exit water levels X 3 exit condition @ each 0 or No water input run.

162 X 2 = 324 data on each comparative test run @ No water input to a single channel.

324 X 5 = 1620 data on 5 sets of comparative tests run with No water input to a single channel.

Conclusion – Basic Fixture Control Flow Vs Free Flow.

[0164] In all the simulated flow test runs with Back-Pressure Control System, the comparing Free Flow run and the BFCF interfered run generally show water level lowered on most condition of flows irrespective of water input ratio mix changes.

[0165] There are high percentage of channel section with lowered water flow level or equal water level in all water exit opening and exit water level conditions with interferent of BFCF.

[0166] In most occasions, more significant improvement result shown under higher water flow level, while the back flow pressure which correspond to its elevated water level.

[0167] Higher back pressure induced water level condition resulted to higher percentages improvement after BFCF interference to water flow.

[0168] The above test is to demonstrate the water level in channel is the summation of input water and back flow induced water.

[0169] The Back-Pressure Control System is to manage the raised water level component due to the back flow water and its backflow energy.

[0170] The test model simulates water flow level changes under different water input to the merging channel confluences. The confluences are at US (Up-stream) merging along to UMS (Upper Mid-Stream), MS (Mid-stream), LMS (Lower-Mid stream) and LS (Lower-stream).

Potential improvement to the current as built open water channel networks

[0171] In the current matured drainage network, there are hundreds of inbuilt flow restrictive elements. The common element are confluence and sharp turn. Such accumulated restrictive flow condition induces back flow pressure resulting to water ponding and overflow. With the BFCF through Back Pressure Control System, we have opportunity to improve water flow to alleviate most of the water ponding or marginal overflow flooding.

[0172] Water level can be lowered only if the elevated water level is induced by Back Pressure Energy and its resultant water flow delay.

[0173] On areas with more serious flood problem, beside installing the BFCF to fix the critical inbuilt channel weakness, with more data available on water level under certain rainfall input condition and its exit discharge condition, we can introduce the Secondary Flow Control Fixtures to further improve flow condition.

[0174] The Secondary Flow Control Fixtures is a custom make fixtures to manage and fit needs to further improve water flow and to lower water level at the relevant section of waterway.

[0175] To manage waterflow, the understanding to a water network is critical, it is easier to understand after observing the water flow condition under a long heavy rainfall covering the whole catchment area. During the long duration of rainfall, when the surface water flow has stabilised, rainwater input is known and recorded with the corresponding waterway water flow level data and its water pressure condition, we can identify the potential risk area for improvement to alleviate the problem.

[0176] With the available real-time waterflow information and understanding of the relative corresponding water level and water pressure data, these data can form as a basic reference for the particular drainage network as a as-built condition under such water input.

[0177] Abbreviations

ABC	Active Beautiful Clean
BPCS	Back-Pressure-Control System
BPMS	Back-Pressure-Management System
BFCF	Basic Flow Control Fixtures
CCD	Confluence-Channel-Divider
CD	Channel-Divider
CV	Crescent-Vane
DDRS	Double-Deck-Reservoir System
DDS	Dry-Drain-System
DHGV	Duplex Holding Gate Vane
GV	Gate-Vane
HG	Holding-Gate
HGV	Holding-Gate Vane
HXV	Holding-X-Gate
SFCF	Secondary Flow Control Fixtures
SGV	Swing-Gate-Vane
TB	Teat-Bump
TPC	Transfer Pump Complex
TPH	Transfer Pump House
V-HG	V-Holding-Gate
VRGV	Vertical-Rotating Gate-Vane
WHC	Water Highway Canal

CLAIMS

1. A method of improving water flow characteristics of an urban open drainage channel network, the network comprising a primary canal and a plurality of secondary canals that discharges to the primary canal comprising:
 - a. identifying sections of the network that are prone to flooding;
 - b. identifying corresponding sections of the network upstream to such identified flood prone sections suitable for installing of controllable flow control means;
 - c. identifying sections of the network downstream to such flood prone sections that have capacity to receive more water when flooding occurs at the identified flood prone sections;
 - d. identifying corresponding sections of the network downstream to such identified flood prone sections suitable for installing of flow improvement means;
 - e. installing of controllable flow control means and flow improvement means at the respective identified sections
 - f. installing controllable flow diverting means to channel water downstream to the identified flood prone sections away to the sections of the network identified that have capacity to receive more water.
2. The method of improving water flow characteristics of an urban open drainage channel network, the network comprising a primary canal and a plurality of secondary canals that discharges to the primary canal according to claim 1 further comprising monitoring rain and flood parameters of the urban open drainage channel network and activating controllable flow diverting means to channel water downstream to the identified flood prone section away to the sections identified that have capacity to receive more water at a predetermined threshold.
3. The method of improving water flow characteristics of an urban open drainage channel network, the network comprising a primary canal and a plurality of secondary canals that discharges to the primary canal according to claim 1 characterised in that the flow improvement means comprises teat bumps, crescent vanes, confluence channel dividers and channel dividers.

4. The method of improving water flow characteristics of an urban open drainage channel network, the network comprising a primary canal and a plurality of secondary canals that discharges to the primary canal according to claim 1 characterised in that the controllable flow control means comprises at least one holding gate.
5. The method of claim 4, whereby the upper edge of the holding gate is profiled for water overflow.
6. The method of claim 5, whereby the lower edge of the holding gate is profiled with an opening gap.
7. The method of claim 6, whereby the holding gate is combined with a deflecting gate vane adjacent to the opening gap to streamline water flow existing from the opening gap.
8. The method of improving water flow characteristics of an urban open drainage channel network, the network comprising a primary canal and a plurality of secondary canals that discharges to the primary canal according to any one of claims 4 to 7 characterised in that the controllable flow control means comprises a plurality of holding gates installed along the length of the canal upstream to such identified flood prone sections.
9. The method of improving water flow characteristics of an urban open drainage channel network, the network comprising a primary canal and a plurality of secondary canals that discharges to the primary canal according to claim 6 characterised in that the opening gap is an inverted V notch and the upper edge of the holding gate is profiled with a V notch.
10. The method of improving water flow characteristics of an urban open drainage channel network, the network comprising a primary canal and a plurality of secondary canals that discharges to the primary canal according to claim 6 characterised in that the opening gap is an inverted V notch and the upper edge of the holding gate is a concave curve spanning the width of the gate.
11. The method of improving water flow characteristics of an urban open drainage channel network, the network comprising a primary canal and a plurality of secondary canals that discharges to the primary canal according to claim 4 further comprising monitoring rain and flood parameters of the urban open drainage channel network and lowering of the at least

one holding gate at a predetermined threshold, thereby increasing holding water level at sections of the network upstream to identified flood prone sections.

12. The method of improving water flow characteristics of an urban open drainage channel network, the network comprising a primary canal and a plurality of secondary canals that discharges to the primary canal according to any one of claims 4 to 11 characterised in that the lifting operation of the at least one holding gate is through auto-floating adjustment relative to water level in the canal, power controlled or manually positioned.
13. The method of improving water flow characteristics of an urban open drainage channel network according to any one of claims 1 to 12 further comprising:
 - a. assessing the flow conditions of the channel network after installation of combination of controllable flow control means, flow improvement means and controllable flow diverting means; and
 - b. installing additional flow improvement means and/or controllable flow control means for additional water flow intervention.
14. An improved urban open drainage channel network system comprising:
 - a. an existing urban open drainage channel network, the network comprising a primary canal and a plurality of secondary canals that discharges to the primary canal, the drainage channel network identified with sections that are prone to floods;
 - b. one or more controllable flow control means adapted to variably impede flow of water installed in the sections of the open drainage channel network upstream to the identified sections that are prone to floods; and
 - c. one or more flow improvement means installed in the sections of the open drainage channel network downstream to the identified sections that are prone to floods.
15. The improved urban open drainage channel network system according to claim 14 further comprising
 - a. sensing means to remotely detect and monitor rain and flood related parameters; and
 - b. controlling means to activate the controllable flow control means upon a predetermined threshold of a monitored parameter.