Simple Water Elevation Transit System

Preliminary Requirements Notes #2

January 27, 2025

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Water Elevation Transit System (WETS) Requirements

Overall Plan

- STEP 1: Consider a manual, single lock WETS to clarify:
  - vocabulary, basic operations, operational policies (KISS)

- STEP 2: Consider a manual, multi lock WETS to further clarify:
  - vocabulary, operations, operational policies (KISS)

- STEP 3:
  - Consider the manual control of a multi transit lane WETS.
  - Consider devices to automate a WETS operation (e.g., hydraulic gates, Electronic valves, water level meters, etc.) and define logical interfaces (e.g., commands, responses, behavior, etc.) to these devices. This assumes there will be a separate Process I/O domain dealing with the lower level communication protocols and presenting the desired behavior.

- STEP 4: Produce a final requirements summary for an automated, multi transit lane, multi lock WETS (KISS)

Vocabulary

- A water elevation transit system enables the transit of water vessels through sloped waterways between an upper level of water and a lower level of water. A WETS may have may transit lanes.

- A transit lane is a distinct path through a WETS. A transit late will have 2 or more gates.

- The movement of a vessel through a transit lane is called a transfer. A transfer to the upper level is called a raise transfer, to the lower level, a lower transfer.

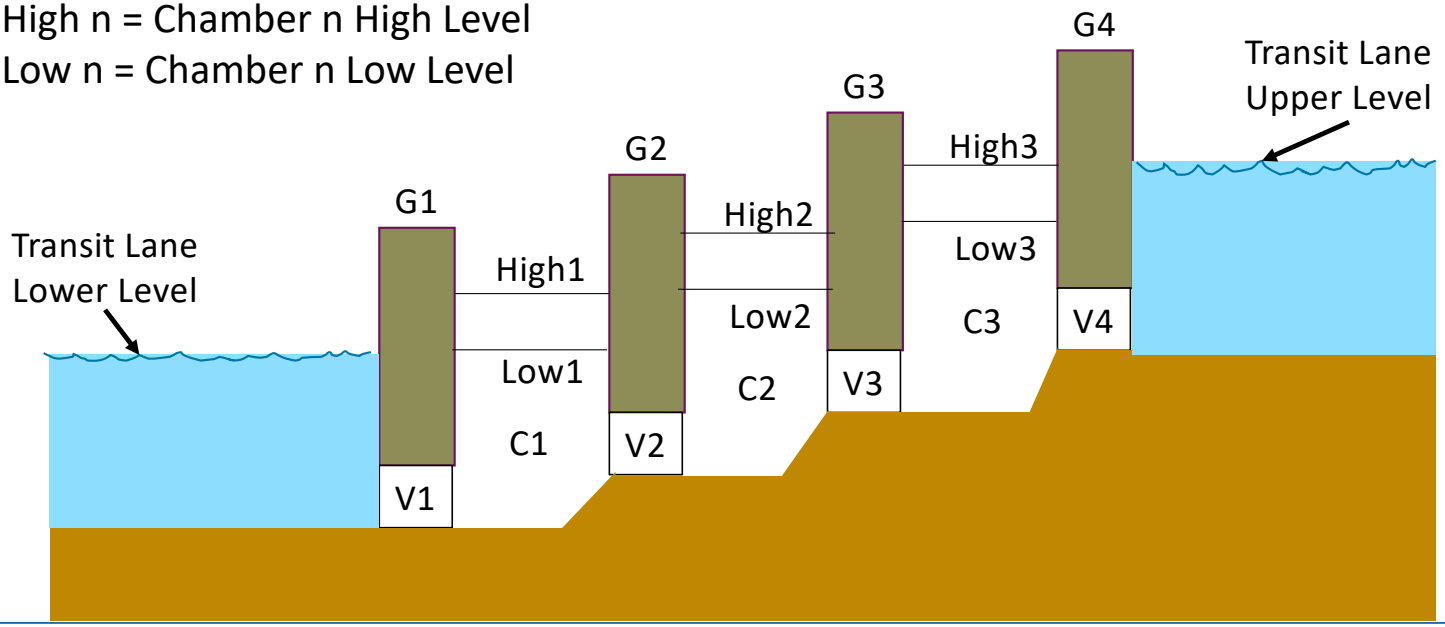
- A gate consists of two doors which can be open or closed to accumulate water or not. Gates contain a culvert allowing water to flow through it. A culvert contains a valve. To control the flow of water through a culvert (open) or not (closed).

- When 2 consecutive gates are closed, the volume between them is called a chamber. Controlling the volume of water in a chamber is how vessels are raised and lowered. A chamber is sometimes referred to as a lock.

Multi Lock Transit Lane

Legend

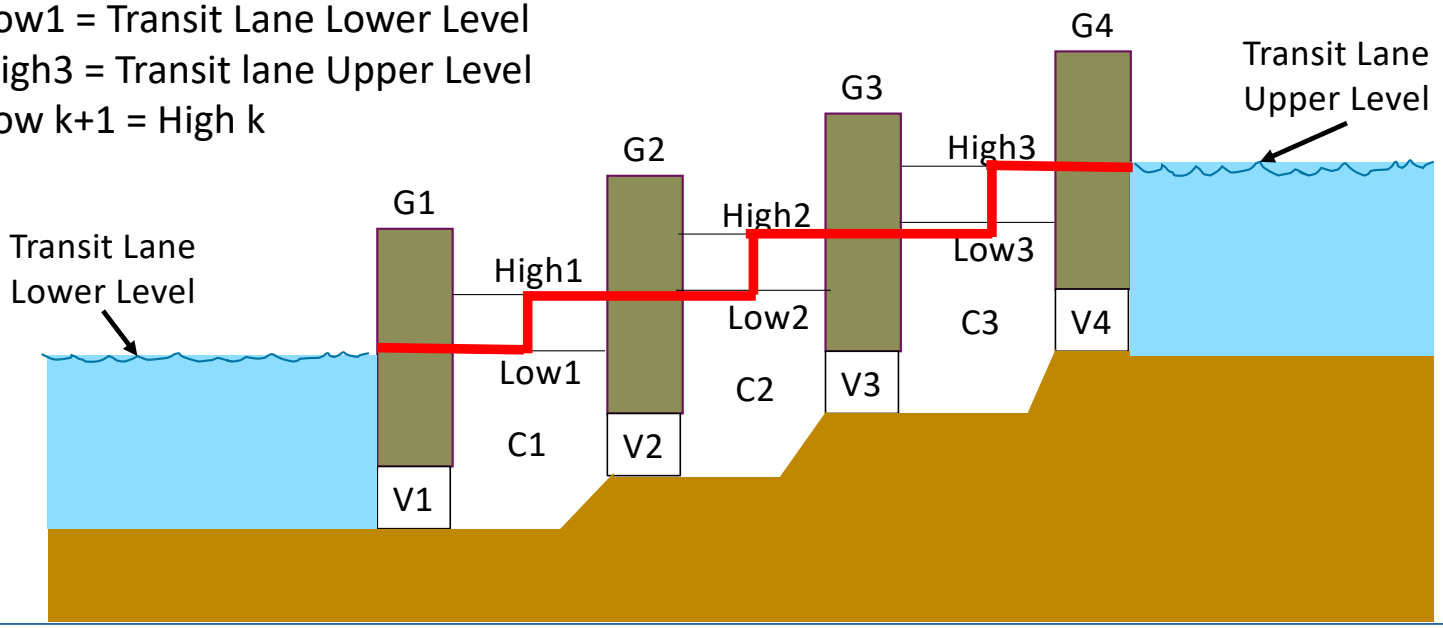
- Gn = Gate n
- Vn = Valve n
- Tn = Tunnel n @Valve n
- Cn = Chamber n
- High n = Chamber n High Level
- Low n = Chamber n Low Level



Multi Lock Transfer

Observation

- For a Raise Transfer, the vessel enters each chamber at its Low level and exits at its High level
- For a Lower Transfer, the vessel enters each chamber at its High level and exits it at its Low level.
- Low1 = Transit Lane Lower Level
- High3 = Transit lane Upper Level
- Low k+1 = High k

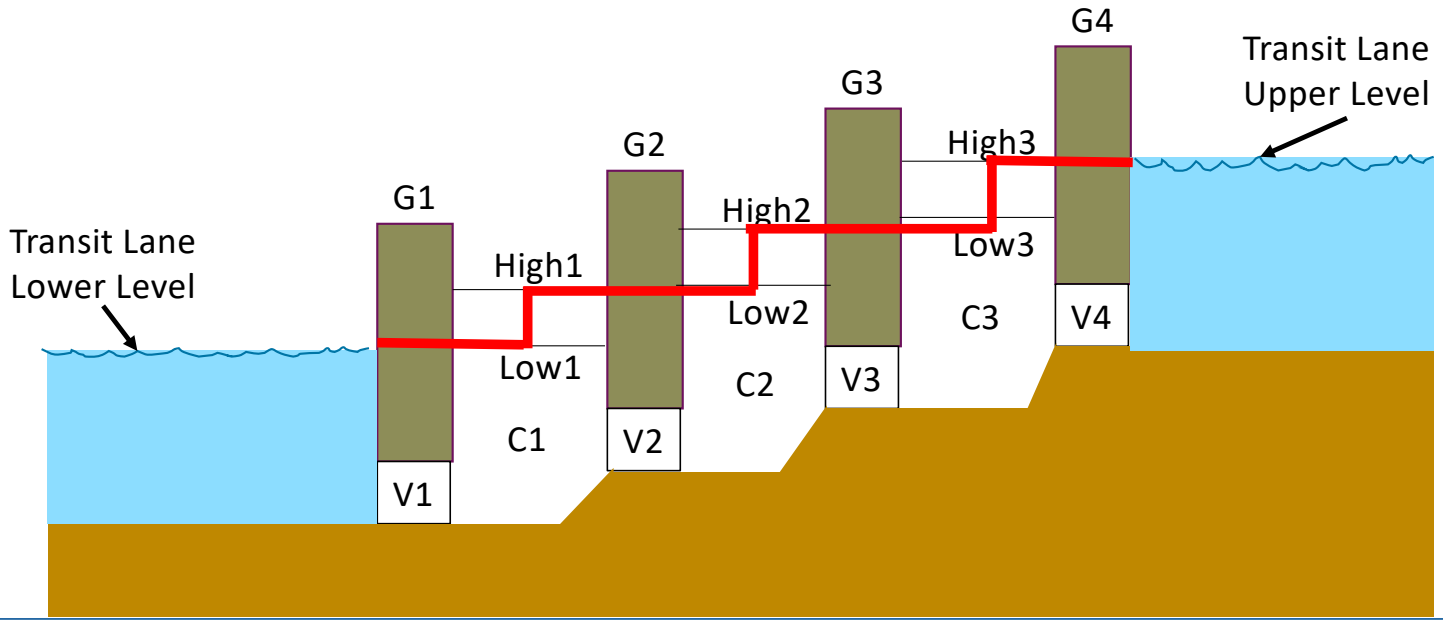


Assumptions for Water Management

Assumptions

- Volume C1=C2=C3
- The High minus Low volume is the same for all chambers
- Transit Lane Upper Level has unlimited water supply
- Transit Lane Lower Level has an unlimited water sink

This is just one set of assumptions that meet the criteria for successfully managing water levels. Paul can elaborate other ones.



Level Requirements for a Raise Transfer

Assumption

All chambers are at required level for the complete transfer, except the entry chamber, and all gates closed before a transfer is initiated.

Level Requirements for a Raise Transfer:

C1 = Low or High

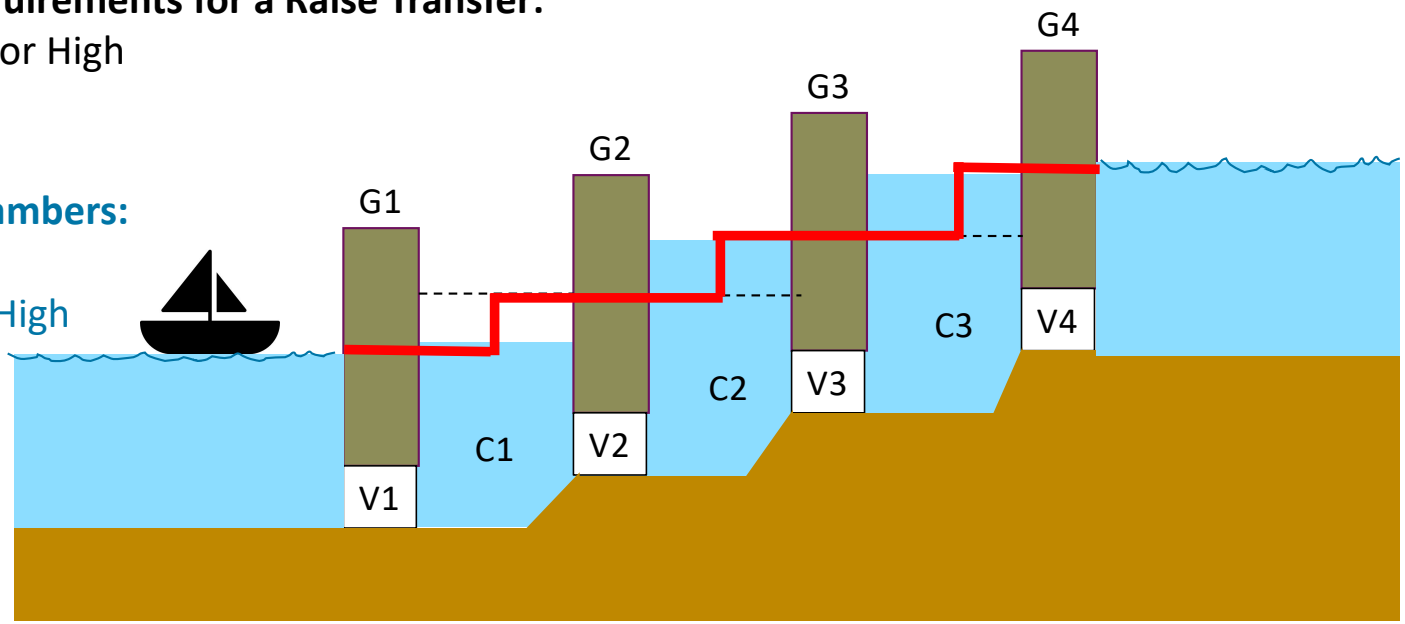
C2 = High

C3 = High

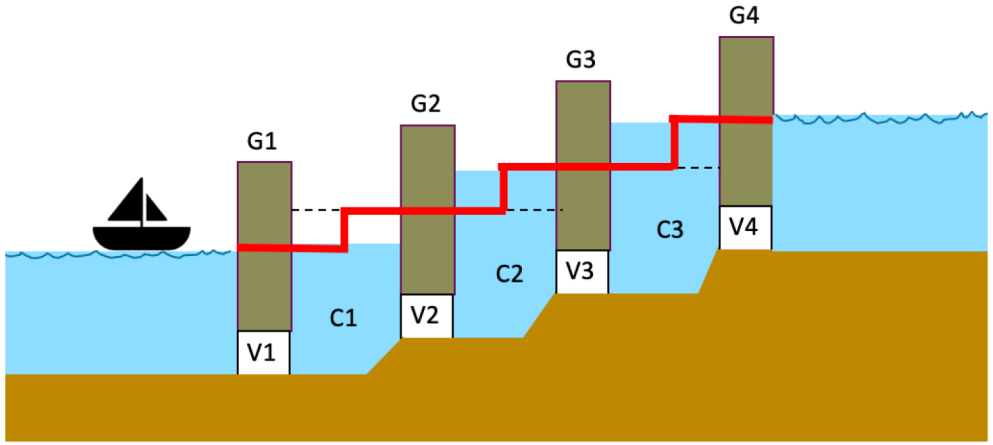
For N Chambers:

C1=Low

C2➔Cn=High



Operations for a Raise Transfer



Start

- Open V1
- When Flow T1 = 0
  - Open G1
- Transfer vessel past G1
- Close G1
- Close V1

- Open V2
- When Flow T2 = 0
  - Open G2
- Transfer vessel past G2
- Close G2
- Close V2

- Open V3
- When Flow T3 = 0
  - Open G3
- Transfer vessel past G3
- Close G3
- Close V3

- Open V4
- When Flow T4 = 0
  - Open G4
- Transfer vessel past G4
- Close G4
- Close V4

End

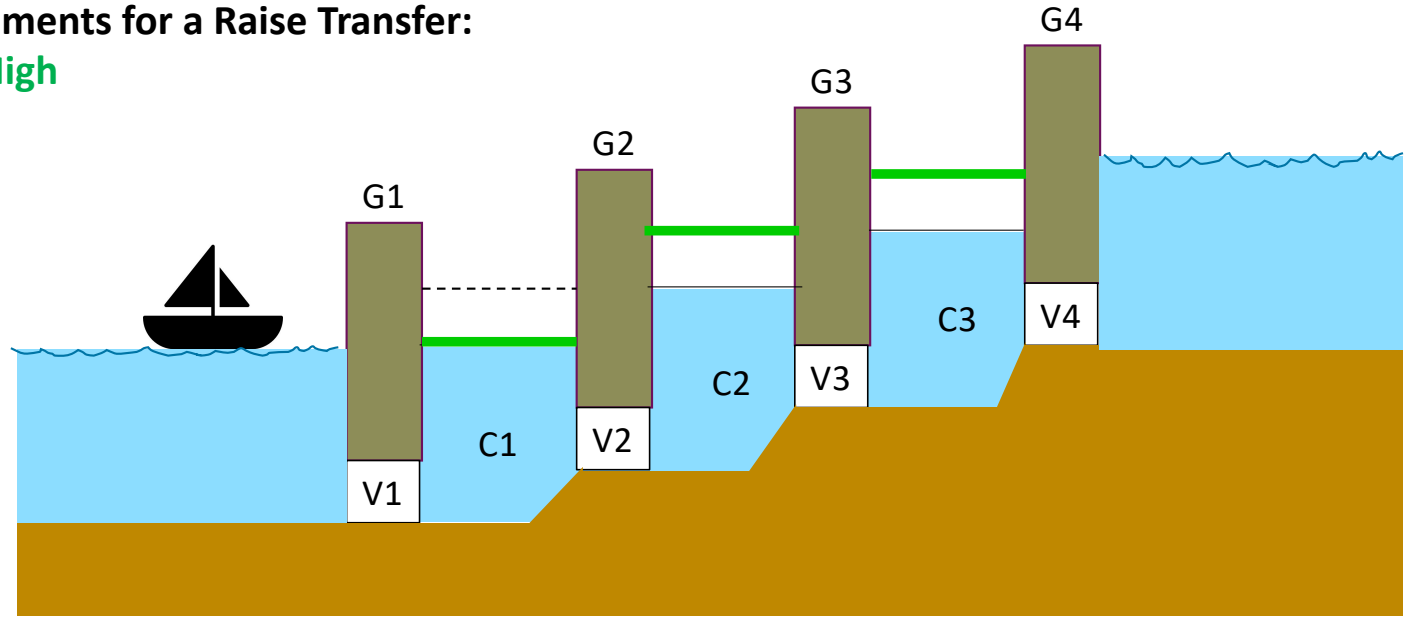
Raise Transfer with Transit Lane @Low Level

Level Requirements for a Raise Transfer:

C1 = **Low or High**

C2 = **High**

C3 = **High**



Required Water Management

- Raise C2 to High
- Raise C3 to High

Operations

- Needs detailed operational steps for valves and feedback from tunnels.

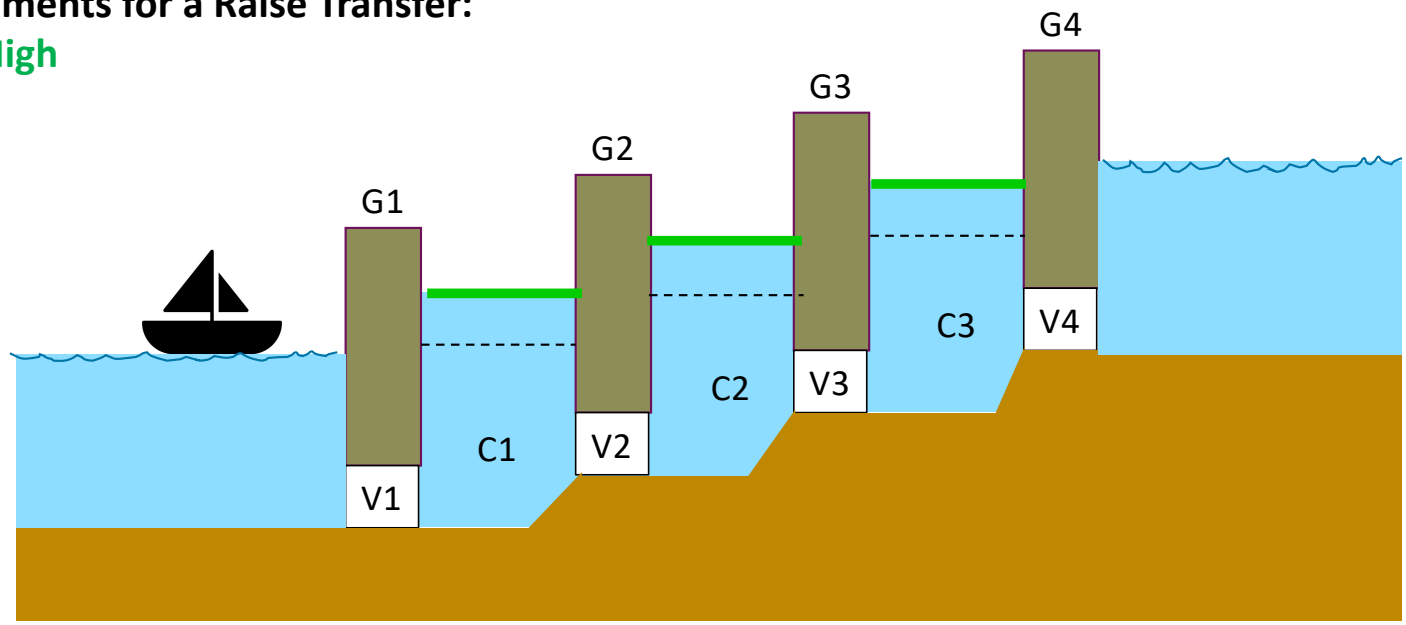
Raise Transfer for a Transit Lane @High Level

Level Requirements for a Raise Transfer:

C1 = **Low or High**

C2 = **High**

C3 = **High**



Required Water Management

- None

Level Requirements for a Lower Transfer

Assumption

All chambers are at required level for the complete transfer, except the entry chamber,and all gates closed before a transfer is initiated.

Level Requirements for a Lower Transfer:

C1 = Low

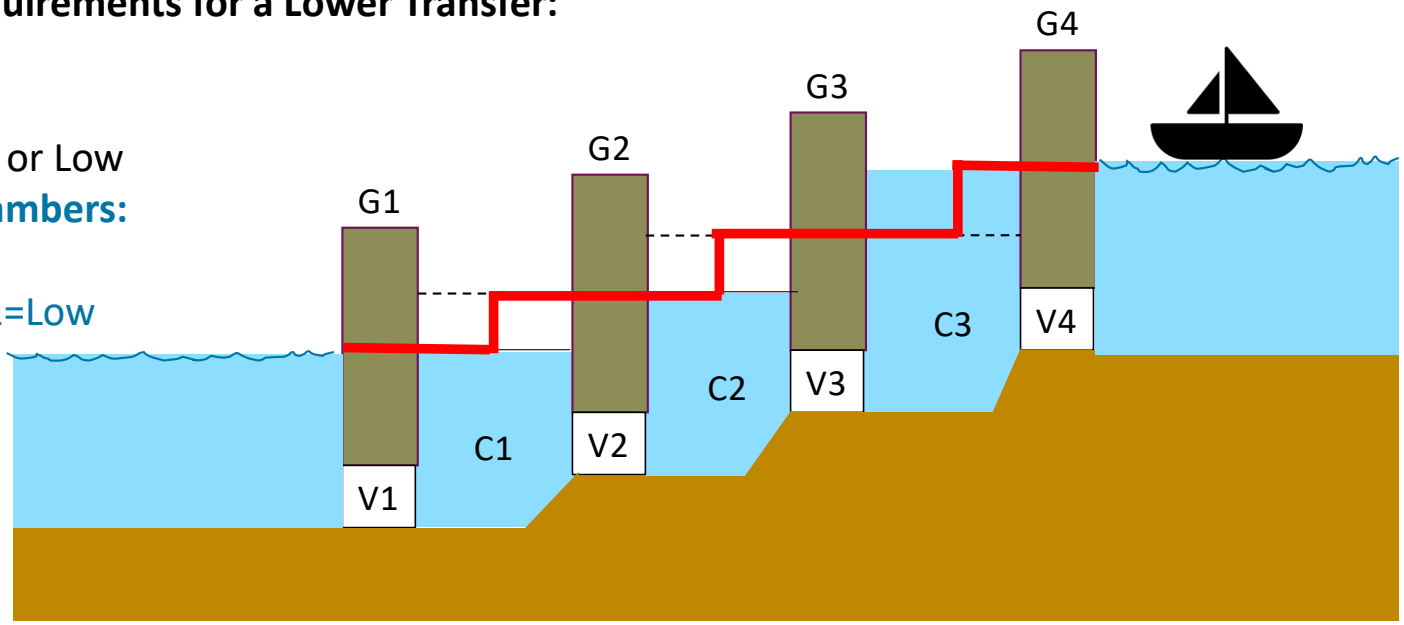
C2 = Low

C3 = High or Low

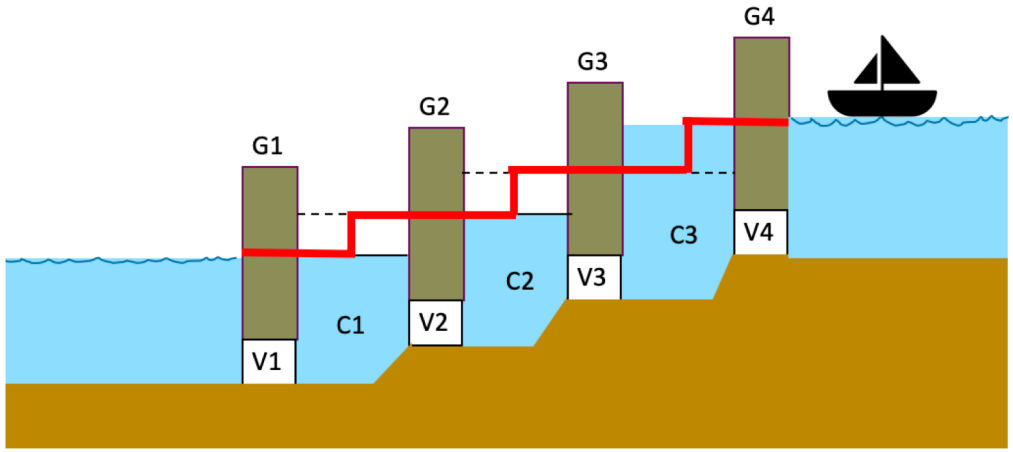
For N Chambers:

Cn=High

C1➔Cn-1=Low



Operations for a Lower Transfer



End

- Open V1
- When Flow T1 =0
  - Open G1
- Transfer vessel past G1
- Close G1
- Close V1

- Open V2
- When Flow T2 =0
  - Open G2
- Transfer vessel past G2
- Close G2
- Close V2

- Open V3
- When Flow T3 =0
  - Open G3
- Transfer vessel past G3
- Close G3
- Close V3

Start

- Open V4
- When Flow T4 =0
  - Open G4
- Transfer vessel past G4
- Close G4
- Close V4

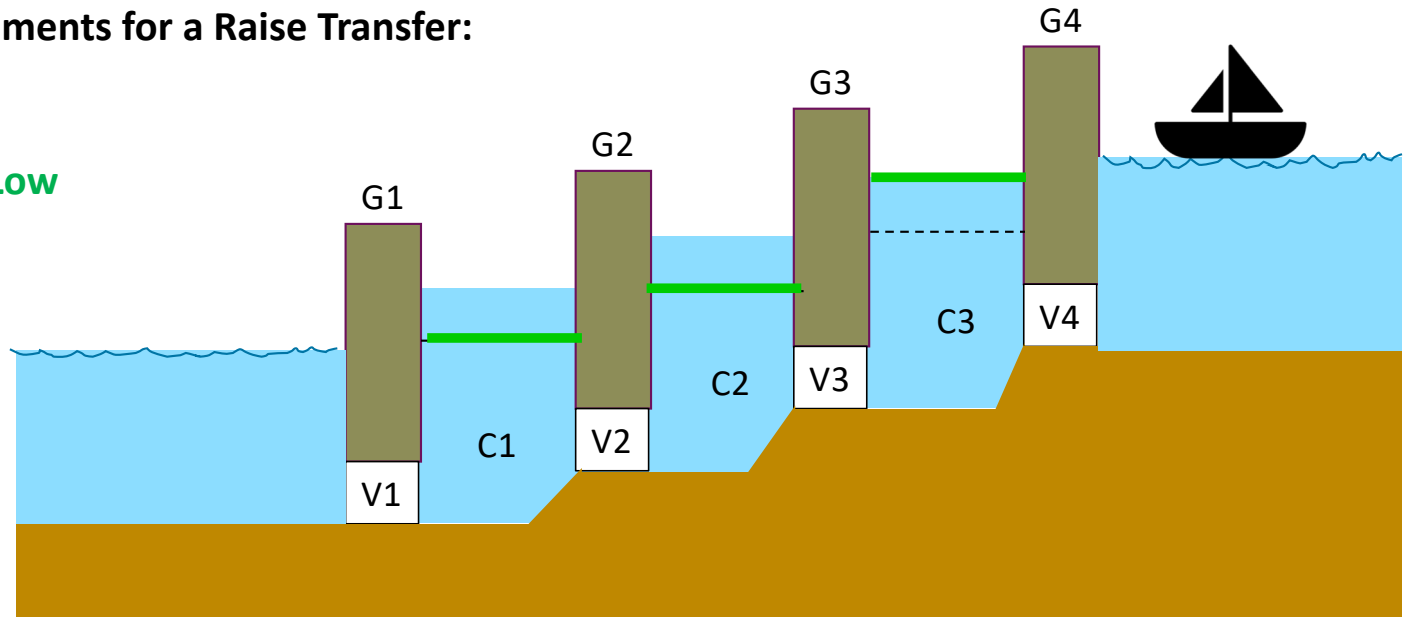
Lower Transfer with Transit Lane @High Level,

Level Requirements for a Raise Transfer:

C1 = **Low**

C2 = **Low**

C3 = **High or Low**



Required Water Management

- Lower C1 to Low
- Lower C2 to Low

Operations

- Needs detailed operational steps for valves and feedback from tunnels.

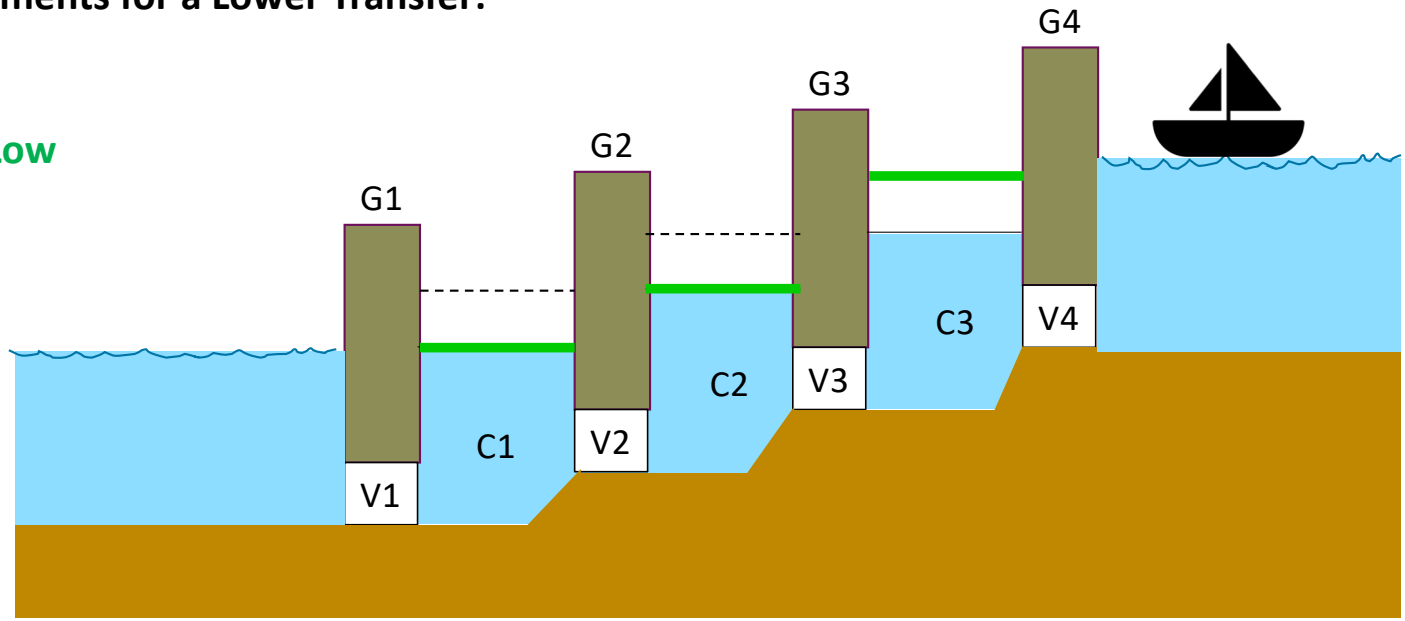
Lower Transfer with a Transit Lane @Low Level,

Level Requirements for a Lower Transfer:

C1 = **Low**

C2 = **Low**

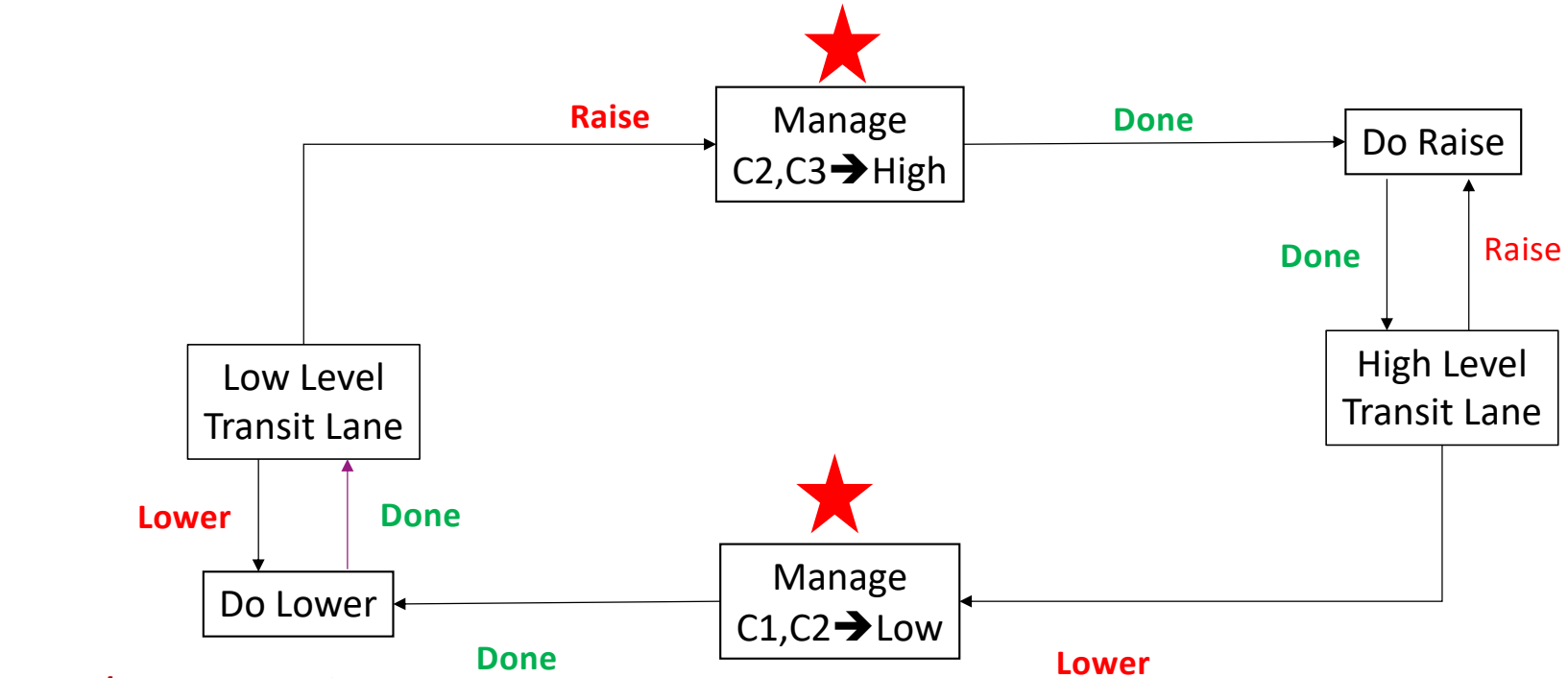
C3 = **High or Low**



Required Water Management

- None

Multi Lock Transit Lane Operations



Raise/Lower = Vessel requests
Done= Activity completion

★ = Additional water management requirements for single lock ➔ multi lock

Next Step

Overall Plan

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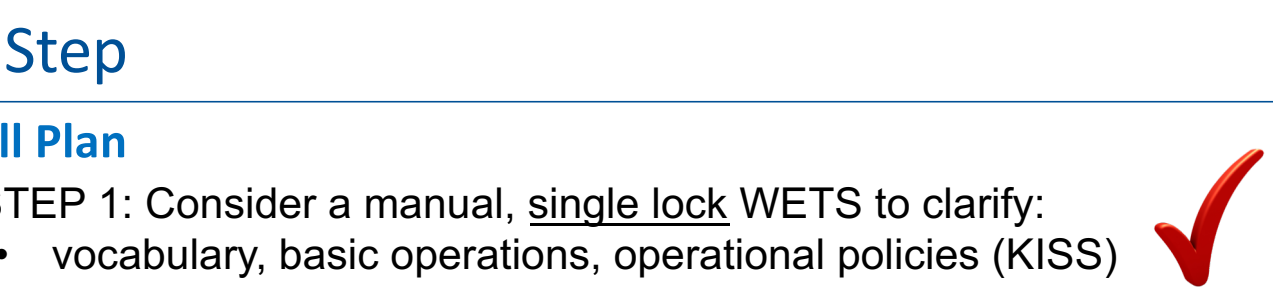

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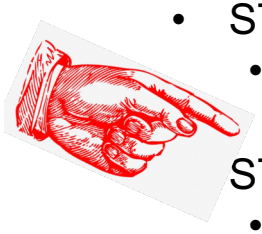

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- Consider devices to automate a WETS operation (e.g., hydraulic gates, Electronic valves, water level meters, etc.) and define logical interfaces (e.g., commands, responses, behavior, etc.) to these devices. This assumes there will be a separate Process I/O domain dealing with the lower level communication protocols and presenting the desired behavior.

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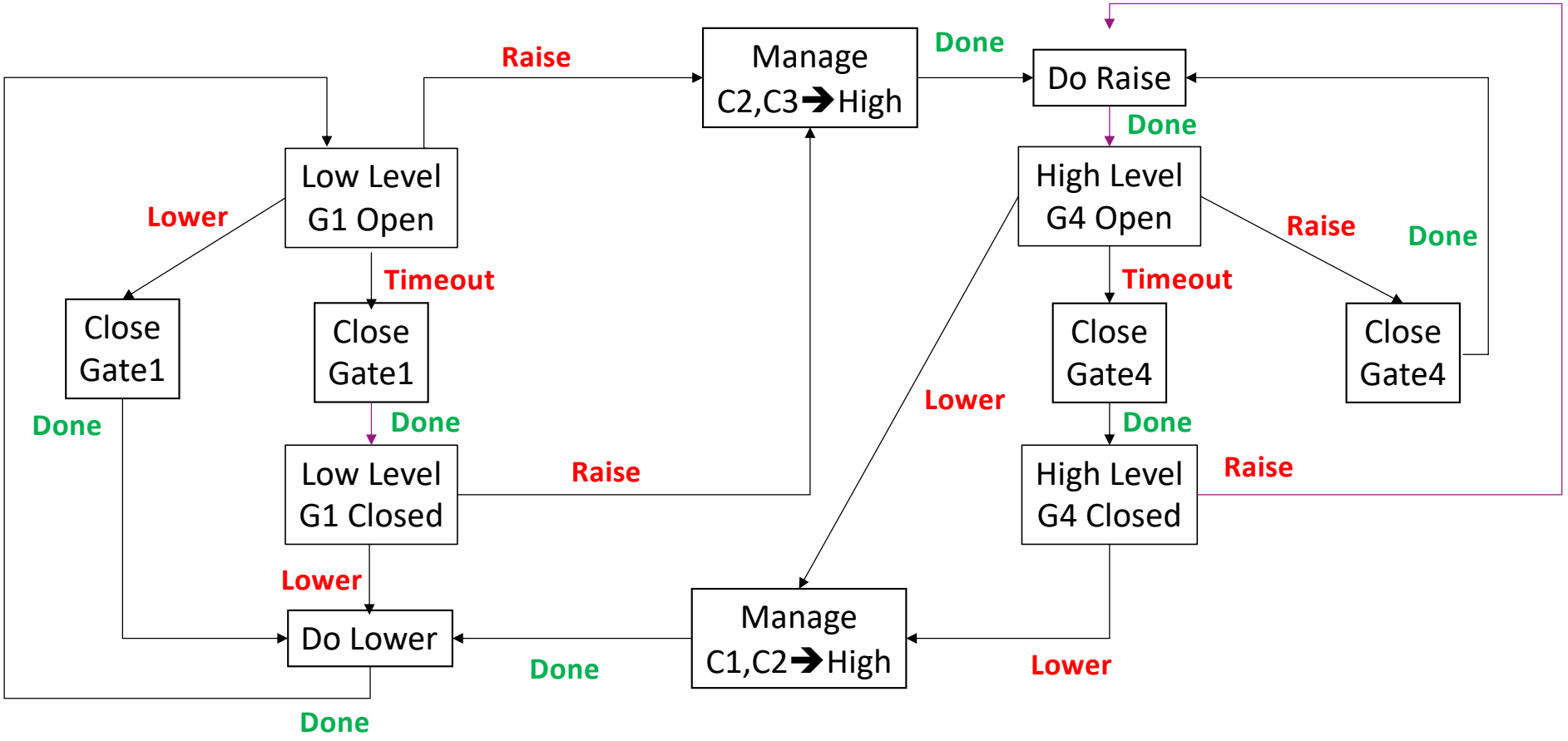
What if?

The exit gate of a transfer will remain open for X minutes after a transfer is completed to avoid reopening that gate if the next transfer starts at that gate within that X minutes. The gate is closed otherwise for safety reasons.

Updated Multi Lock Transit Lane Operation



Questions? Comments?? Suggestions???