The Engineering Division shall not approve any drainage report pertaining to proposed construction, platting or other development where the proposed activity or change in the land would result in post-development discharge from the site exceeding discharge under pre-developed conditions (for new development) or existing conditions (for re-development). Downstream capacity shall not be exceeded as a result of development. Exemptions from this provision are as follows:

A. Additional drainage improvements are not required if drainage improvements have been provided for the fully developed condition, which includes the proposed development.
B. Prior written approval of a Stormwater Connection Fee from the City Engineer.

No proposed development shall be constructed which impedes or constricts runoff from an upstream watershed based on fully developed conditions. Therefore drainage computations shall be provided to verify no adverse impact upstream or downstream.

2.3 Freeboard

Freeboard is the vertical distance between the design water surface and the elevation of the drainage facility, such as the top of channel, ditch or detention pond. Freeboard is intended to provide a factor of safety and prevent the fluctuation of the water surface from overflowing the drainage facility. Freeboard requirements are shown in Table 2-2~~Table 2-2~~. Freeboard is not required where parking areas are designed to serve as detention facilities; however, site design should consider safety and drainage overflow location.

Table 2-2: Freeboard Requirements

Drainage Facility	Design Frequency	Minimum Freeboard
Street right-of-way	100-year	None
C~~hannels and c~~reek improvements	100-year	1.0 ft
Channels with drainage area > 128 acres	100-year	1.0 ft
Channels with drainage area ≤ 128 acres		
• 100-year design depth < 5 ft	100-year	25-year + 0.5 ft
• 100-year design depth 5-10 ft	100-year	25-year + 10% design depth
• 100-year design depth > 10 ft	100-year	25-year + 1.0 ft
~~Swales and ditches[1]~~	~~25-year~~	~~0.5 ft~~
Detention ponds and reservoirs	100-year	1.0 ft
Bridges and culverts	25-year	See note *2*
Floodways and floodplains	100-year	2.0 ft (See note *3*)

[1] *Channels with drainage area ≤ 128 acres shall be designed to contain the 100-year storm event or 25-year storm event plus freeboard, whichever is greater~~Swales or ditches are considered to have drainage areas of 128 acres or less~~.*

[2] *Bridges and culverts shall be designed to withstand the 100-year event, but the water level may reach roadway level at the 25-year design level if no public safety issues are involved.*

[3] *Floodways and floodplains shall have a minimum of 2-feet freeboard or the minimum freeboard established in the most recently adopted Floodplain Ordinance.*

Formatted Table

Formatted: List Paragraph, Bulleted + Level: 1 + Aligned at: 0" + Indent at: 0.25"

Formatted: List Paragraph, Bulleted + Level: 1 + Aligned at: 0" + Indent at: 0.25"

Formatted: List Paragraph, Bulleted + Level: 1 + Aligned at: 0" + Indent at: 0.25"

Formatted Table

included in the rivers and stream data set published in the United States Geological Survey (USGS) National Hydrography Dataset (NHD) in 2013 was considered a stream.

2.9 Water Quality Controls

Temporary water quality best management practices (BMPs) shall be required when any disturbance could result in appreciable erosion that could result in measurable accumulation of sedimentation in dedicated streets, alleys, any waterway or other private properties during construction activities. Site erosion control requirements are provided in **Section 12**.

Development and redevelopment located over the Edwards Aquifer regulatory zones shall comply with the latest TCEQ published rules and technical design guidance for the Edwards Aquifer. Permanent water quality BMPs for development outside of the Edwards Aquifer regulated zones shall be designed to provide adequate treatment of the water quality volume in the City's jurisdiction as defined in **Section 13**.

2.10 Maintenance of Drainage Facilities

The property owner or designee will maintain the hydraulic integrity of drainage systems not dedicated to the City. The City will maintain the hydraulic integrity of drainage systems dedicated to and accepted by the City. Maintenance of the floodplain, drainage easements, and water quality features shall be explicitly stated in a recorded instrument.

2.10.1 Maintenance Schedule

A maintenance schedule supported by engineering or scientific published documents shall be submitted to the Engineering Division prior to approval of construction plans for public and private facilities. The City has the right to conduct periodic inspections of privately owned and maintained drainage and water quality improvements to ensure that the maintenance schedule is being implemented.

2.10.2 Maintenance Access

Access shall be provided for all channels to allow equipment access for maintenance. Access shall have a width of at least 12 feet and a cross slope no greater than two percent. Maintenance ramps used for access shall have a vertical grade no steeper than 6:1. An unobstructed access easement connecting the channel drainage easement with a roadway parallel to or near the easement shall be provided at a minimum spacing of one access easement at a minimum of 1,000 feet intervals. Access shall be provided within dedicated right-of-way or within the drainage easement dedicated for the channel. The bottom of the channel cannot be considered as maintenance access.

2.11 Pumped Drainage Facilities

The City of New Braunfels discourages the use of Pumped Drainage Facilities. A Pumped Drainage Facility is defined as any drainage system not wholly utilizing gravity outflow. Facility designs considered under this section's guidelines must first demonstrate that a gravity system is not feasible from both an engineering and economic standpoint. A feasibility analysis is required to be submitted prior to permit application. The applicant must have expressed written approval from the City Engineer and Engineering Division with permit application.

8 Open Channels

8.1 General Requirements

The general classifications for open channels are: (1) Natural channels, which include all watercourses that have been carved by nature through erosion; and (2) Engineered channels, which are constructed or existing channels that have been significantly altered by human effort.

A. The City of New Braunfels encourages the preservation of natural channels and drainage patterns. Developed drainage flows must enter and depart from a developed area in the same manner and location as under pre-development conditions. Any concentration of previous over-land flow is required to leave the developed site into a receivable body such as a drainage easement or city right-of-way in a manner so as to not impact downstream properties and/or facilities.

B. Easements or drainage rights-of-way shall be provided for all open channels such that the 100-year runoff and maintenance access are~~is~~ contained within drainage easements and/or right-of-way. Drainage easements shall be designated on plats for recording. For properties with existing structural development on previously platted lots, additional drainage easements shall be dedicated by separate recorded instrument or an amended plat. Easements and FEMA floodways shall not be encroached upon with fill materials or structures, which would reduce the channel's ability to carry the 100-year flood.

    a. Easement width shall be at least the width of the water surface from the 100-year design storm runoff under post-development conditions plus maintenance access. Maintenance access shall extend 2 feet from one side of the channel and 12 feet on the other side of the channel. If a channel is located parallel and adjoining a roadway, maintenance access shall extend 2 feet from both sides of the channel. ~~A clear width of 14 feet, minimum, shall be included in the drainage easement width for access.~~

    b. Additional easement width should be provided to allow for channel meandering near bends of channels

C. Engineered channels ~~and swales~~ shall be designed to meet the applicable design, freeboard and easement requirements. Freeboard along the outside of channel bends shall include the increased water surface due to superelevation.

D. Fencing and/or warning signs should be required to prevent public access where flowing water would pose a safety hazard. Fencing shall be designed in such a way as to not pose a drainage obstruction.

E. Shear stress shall be computed for all open channels and adequate protection provided in accordance with *Hydraulic Engineering Circular 15: Design of Roadway Channels with Flexible Linings (HEC 15)* [9]. Channels shall be designed to be stable and to not create safety hazards. Side slopes of vegetative lined channels should be 3:1 or flatter (4:1 or flatter along roadways) in channels with depths greater than 2 feet. Recommended maximum water velocities for earthen channels are given in Table 8-1. Erosion control or energy dissipation devices should be used to control velocities such

that channel degradation does not occur. Bank stabilization measures shall not reduce channel capacity and shall follow sound engineering practices

Table 8-1: Maximum Velocity in Open Channels

Channel Lining Material[1]	Channel Slope (%)	Maximum Velocity (fps)
Earthen Channels	0 – 5	6
	5 – 10	5
	> 10	4
Rock (native subgrades)		10
Gabion Lined		12
Reinforced concrete lining		20
Rock Riprap (placed rock)		12
Prefabricated lining products		Use 90% of manufacturer's recommended velocity limits

[1] *Uniform, in well-maintained condition.*

F. Should diversion of a natural drainage way be required, sufficient work shall be done upstream and/or downstream to provide all affected properties at least the same level of flood protection and erosion control that existed prior to the diversion. The time length of a diversion channel must be at least as long as the segment of natural channel being replaced so that velocity is not increased.

G. Fencing shall be required adjacent to the channel where channel vertical wall heights exceed 2 feet and where channel side slopes exceed 2:1 and the depth is greater than 2 feet. Fencing shall be a minimum of 42" high, provide for maintenance access and not hinder sight distance for traffic. Fence type and location shall be determined by the design engineer.

~~F.~~H. Concrete pilot channels shall be provided for channels with longitudinal slopes less than 0.5 percent or bottom widths greater than 30 feet. The minimum bottom width of the pilot channel shall be 4 feet and the minimum earthen slope draining toward the pilot channel shall be 1 percent.

8.2 Design Criteria

A. The depth and velocity of flow are necessary for the design and analysis of channel linings and structures. The depth and velocity at which a given discharge flows in a channel of known geometry, roughness, and slope can be determined through hydraulic analysis. The following two methods are commonly used in the hydraulic analysis of open channels:

1. Slope Conveyance Method
2. Standard Step Backwater Method

The Slope Conveyance and Standard Step Backwater Methods have been summarized from the *TxDOT HDM*.

B. Channels should have sufficient gradient, depending upon the type of soil or channel lining material, to provide velocities that will be self-cleaning (greater than 2 feet per second for the 2-year storm event) but not cause erosion due to excessive shear stress.

Appendix B: Definition of Terms

Abstractions. The fractions of precipitation lost to evaporation, transpiration, interception, depression storage and infiltration.

Abutment. A wall supporting the end of a bridge or span, and sustaining the pressure of the abutting earth.

Apron. A floor or lining of concrete, timber, or other suitable material at the toe of a dam, entrance or discharge side of spillway, a chute, or other discharge structure, to protect the waterway from erosion from falling water or turbulent flow.

Backwater. The rise of the water level upstream due to an obstruction or constriction in the channel.

Backwater Curve. The term applied to the longitudinal profile of the water surface in an open channel when flow is steady but non uniform.

Baffle Chute. A drop structure in a channel with baffles for energy dissipation to permit the lowering of the hydraulic energy gradient in a short distance to accommodate topography.

Baffles. Deflector vanes, guides, grids, gratings, or similar devices constructed or placed in flowing water, to: (a) check or effect a more uniform distribution of velocities; (b) absorb energy; (c) divert, guide, or agitate the liquids; and (d) check eddy currents.

Base Flood. The flood having a one percent chance of being equaled or exceeded in any given year.

Calibration. Process of checking, adjusting, or standardizing operating characteristics of instruments and model appurtenances on a physical model or coefficients in a mathematical model. The process of evaluating the scale readings of an instrument in terms of the physical quantity to be measured.

Channel. Natural or engineered open waterway designed to convey stormwater runoff.~~Any path of concentrated flow that conveys storm runoff from a drainage area greater than 128 acres.~~

Channel Roughness. Irregularities in channel configuration which retard the flow of water and dissipate its energy.

Channel stability. A condition in which a channel neither degrades to the degree that structures, utilities or private property are endangered, nor aggrades to the degree that flow capacity is significantly diminished as a result of one or more storm runoff events or moves laterally to the degree that adjacent property is endangered.

Channel treatment measure. A physical alteration of a channel for any purpose.

Chute. An inclined conduit or structure used for conveying water to a lower level.

b. **On site detention.** A detention pond which is located within and serves only a specific site or subdivision.
c. **On stream detention.** Detention facilities provided to control excess runoff based on a watershed wide hydrologic analysis.

Developed land. Any lot or parcel of land occupied by any structure intended for human occupation, including structures intended for commercial or industrial enterprise.

Developer. Any individual, estate, trust, receiver, cooperative association, club, corporation, company, firm, partnership, joint venture, syndicate or other entity engaging in platting, subdivision, filling, grading, excavating, or construction of structures.

Ditch. Open waterway typically used to convey stormwater runoff alongside roadways.

Formatted: Font: Not Bold

Downstream capacity. The ability of downstream drainage facilities to accept and safely convey runoff generated upstream.

Drainage basin. The storm water catchment area above a point on a channel to which waters drain and collect. Watershed has the same meaning.

Drainage control. The treatment and/or management of surface runoff.

Drainage easement. A platted area reserved for the primary purpose of stormwater drainage and maintenance.

Drainage System. Drainage systems shall include streets, alleys, storm drains, drainage channels, culverts, bridges, overflow swales and any other facility through which or over which storm water flows.

Drop Inlet. A storm drain intake structure typically located in unpaved areas. The inlet may extend above the ground level with openings on one or more sides or it may be flush with the ground with a grated cover.

Drop Structures. A sloping or vertical section of a channel designed to reduce the elevation of flowing water without increasing its velocity.

Entrance Head. The head required to cause flow into a conduit or other structure; it includes both entrance loss and velocity head.

Entrance Loss. Head lost in eddies or friction at the inlet to a conduit, headwall or structure.

Erosion control. Treatment measures for the prevention of damages due to soil movement and to deposition.

Evaporation. Process by which water is transferred from land and water masses to the atmosphere.

Excavation. Digging and removal of earth by mechanical means.

Stilling Basin. Pool of water conventionally used, as part of a drop structure or other structure, to dissipate energy.

Storm Hydrology. The branch of hydrology that concentrates on the calculation of runoff from storm rainfall.

Stormwater Management. The control of storm runoff by means of land use restrictions, detention storage, erosion control, and/or drainage systems

Stormwater Model. Mathematical method of solving stormwater problems by computer technology.

Streets. The classifications and descriptions of streets, such as alley, arterial, collector, freeway, local, parkway, etc., established by the City of New Braunfels in the Thoroughfare/Transportation Plan.

Subcritical Flow. Relatively deep, tranquil flow with low flow velocities. The Froude Number is less than 1.0 for subcritical flow conditions.

Supercritical Flow. Relatively shallow, turbulent flow with high velocities. The Froude Number is greater than 1.0 for supercritical flow conditions.

Swale. A low lying or depressed stretch of land without a defined channel or tributary.

Tailwater. The depth of flow in the stream directly downstream of a drainage facility or other man made control structure.

Temporary drainage facility. A non-permanent drainage control, flood control or erosion control facility constructed as part of a phased project or to serve until such time that a permanent facility is in place, including but not limited to desilting ponds, berms, diversions, channels, detention ponds, erosion control measures, bank protection and channel stabilization measures.

Time of Concentration. The estimated time in minutes required for runoff to flow from the most hydraulically remote section of the drainage area to the point at which the flow is to be determined. Hydraulically remote refer to the travel path with the longest flow travel time, not necessarily the longest linear distance.

Total Head Line. A line representing the energy in flowing water. The elevation of the energy line is equal to the elevation of the flow line plus the depth plus the velocity head plus the pressure head.

Trash Rack. Racks, gratings, or mesh designed so as to prevent tree limbs, water borne debris and rubbish from plugging the outlets from a dam or detention basin.

Trunk Line. The main line of a storm drain system, extending from manhole to manhole or from manhole to outlet structure.

Ultimate Development. The condition of the watershed after the entire watershed has undergone development.